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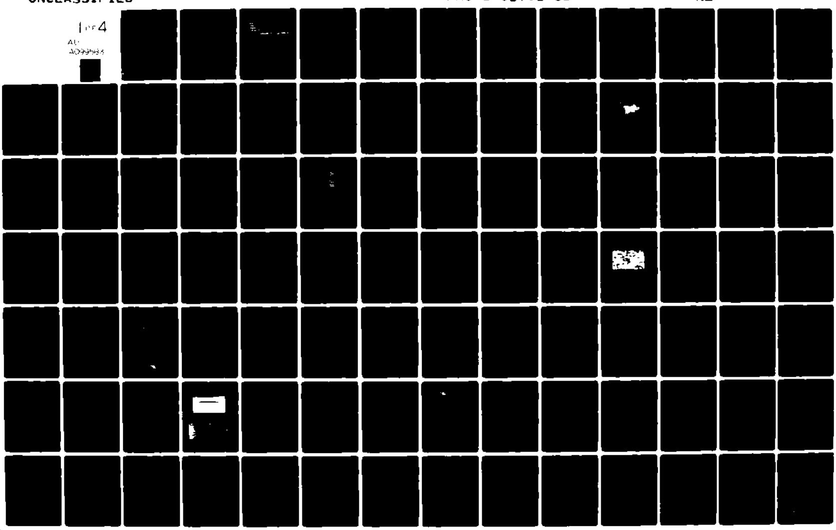

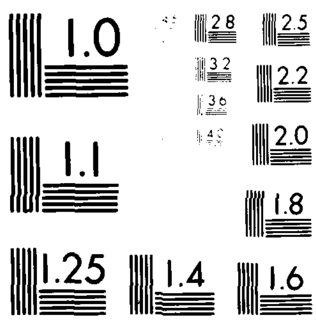

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared from data gathered between 1976 and 1980 through funding from the Army Research Office. It also contains interpretation and corroborative material developed through funding from various Federal agencies and private sources dating from 1960. The objectives are: (1) To trace the development of soils, especially those of the wet tundra, and their relationship to associated microtopography. (2) To determine to what extent the wet tundra soils and their related microtopography are the products of a cyclic repetition

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20. ABSTRACT CONTINUED

of events involving vegetation succession and hydrologic changes (tussock tundra) or, in the case of the very wet polygonized tundras, are the products of an evolutionary sequence leading to the abolition of the pattern and the creation of a new landform-soil association; (3) To determine the time frame in which these processes occur and thus gain an understanding of the temporal stability of the soils and landforms along the regional gradients and within selected mesogradients; (4) To produce a detailed series of soil-landform maps and soil characterizations for selected areas along the gradients using the techniques developed for the coastal plain tundra.

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SOIL-LANDSCAPE RELATIONS AT SELECTED SITES ALONG ENVIRONMENTAL GRADIENTS IN NORTHERN ALASKA

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For the Period
August 1, 1979 - January 31, 1981

DEPARTMENT OF THE ARMY
U. S. Army Research Office
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Soil-Landscape Relations at Selected Sites Along Environmental Gradients in Northern Alaska

Final Report

Army Research Organization

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K. R. Everett

April
1981

Preface

This report was prepared from data gathered between 1976 and 1980 through funding from the Army Research Office. It also contains interpretation and corroborative material developed through funding from various Federal agencies and private sources dating from 1960. These have included the U. S. Atomic Energy Commission (DOE), National Science Foundation; U. S. Army Cold Regions Research and Engineering Laboratory and the Prudhoe Bay Environmental Subcommittee of the Alaska Oil and Gas Association.

The materials presented in the following pages represent a final report. However, they have been refined over the period of study, which in fact explains inconsistencies, especially in taxonomic designations, of soils and explanations of their genetical and historical development. Further refinements are to be expected in publications based on these data. Many of the data in this report have been made available during its preparation to various individuals and agencies concerned with soils-landform-vegetation problems, especially mapping programs north of the Yukon River.

A very large number of individuals have contributed directly and indirectly to the study. Particular recognition is due Dr. Jerry Brown, U.S.A. CRREL who has encouraged the study from the beginning and has contributed substantial amounts of his time and administrative skill toward its completion. Drs. Patrick Webber and Donald A. Walker have cooperated to the fullest in sharing scientific expertise and logistics. The U. S. Geological Survey represented by Drs. Max Bewer and John Haugh have been of great assistance with logistic arrangements within the area of the

National Petroleum Reserve. Messrs. Timothy Meyers, Daniel Cronner and Nicholas Bull have assisted in various phases of the field work. Personnel of The Ohio State University Department of Agronomy Soil Characterization Laboratory directed by Mr. Michael Ransom have provided the careful chemical and physical analyses displayed in the tables and graphs that accompany this report. Mrs. Bonita Crawford assisted with much of the data compilation. Figures and tables were drafted by Mr. Robert Tope and Mrs. Jean Cothran typed all phases of the report.

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Introduction

Fundamental research on arctic soils in the Northern Hemisphere is historically a rather recent event. Beginning in the mid 1950's these soils have been a subject of ever-increasing interest for a little over 20 years. It is probably safe to say that the investigations of Tedrow and his students and colleagues (Tedrow, 1973) together with those of Ugolini and Tedrow (1963), Rieger (1966, 1974), Holowaychuk et al. (1966) and those of the U.S. Tundra Biome have recognized most, if not all, major soil types of northern Alaska. The generalized distribution of these soils within the region as outlined by Tedrow and Brown (1967), Rieger (1974) and Rieger et al. (1979) is probably correct. The major soil boundaries portrayed on a series of 1:1,000,000 maps (Reiger et al. (1979) closely follow the principal physiographic boundaries drawn by Wahrhaftig (1965). Thus the regional aspects of geology, drainage and climate are recognized.

Drew (1957), Brown (1962), and Holowaychuk et al. (1966) record the first attempts in the Alaskan tundra to relate soils and landscape elements at the more conventional soil mapping scales (1:31,680 - 1:15,840). At these scales, morphologic as well as physical and chemical relationships to landscape elements and moisture gradients, come into focus. Gross similarities between soils and vegetation units also become apparent when maps are compared.

From approximately 1970 on, a major thrust in arctic research has been toward an understanding of the dynamics of the tundra ecosystem.

The approach has involved primarily an interdisciplinary and international effort including most prominently the biological sciences, soil science (pedology), geomorphology and climatology. This effort required a still sharper focus (scales of 1:500) on the relationships among landscape elements, soils and vegetation, including specific soil physical and chemical characteristics between microrelief components, (Brown et al. 1980; Carey, 1972; Gersper, 1972; Gersper et al., 1974; Everett, 1973; and Everett et al., 1980). Concurrent Tundra Biome related studies in the Prudhoe Bay area (Everett, 1975; Webber, 1975; Walker et al., 1980) have demonstrated strong interrelationships among the parameters outlined above. The techniques of soil-landform mapping as well as the vegetation-landform mapping of Webber and his students which were developed principally at Prudhoe Bay were expanded to approximately 145 km^2 in that area and extended to a 36 km^2 area at Meade River, Alaska, the latter in conjunction with a multidisciplinary investigation of grazing impacts on tundra (Komárková and Webber, 1980; Everett, 1980).

Because these studies and their counterpart investigations, especially in the Taimyr area of Soviet Union have dealt primarily (but not exclusively) with wet coastal tundra environments (Everett et al., 1980), it is appropriate to exapnd our recently acquired knowledge of the dynamics of these environments to other climatically different areas of the arctic, and to examine the relationships, in this case of soil-landform interactions, along climo-topographic gradients which have hitherto been logistically inaccessible.

The detailed investigations of soil-vegetation-landform patterns at Barrow, Prudhoe, and Meade River, Alaska, show a close relationship

between vegetation assemblages and soils at all mapping scales. Such a general correspondence was of course to be expected. At Barrow a regionally significant detail similarity was apparent at mapping scales as large as 1:300 (Brown et al., 1980). The documentation of this relationship and the fact that it can be mapped on aerial photographs with a high degree of reliability permits a cautious extrapolation of some of the more dynamic aspects of the ecosystem which are related to these patterns. For example, it has been clearly shown that nutrient distribution within tundra soils (and vegetation) undergoes not only significant fluctuations during the thaw season but also that differences in distribution in nutrient patterns are clearly established among the different soil-microrelief (landform) elements (Brown et al., 1980; and Bilgin, 1975). Similar relationships can be demonstrated for a wide array of variables including seasonal thaw patterns and soil temperature (Everett, 1975; MacLean et al., 1974; Matveeva, 1971; Brown and Rickard, 1969), and the distribution of soil arthropods (MacLean, 1974). Although these relationships have been studied most thoroughly in wet meadow-low center polygon coastal plain tundra, recent investigations in tussock tundra areas at Meade River and along the Yukon River-Prudhoe Bay transportation corridor (Brown and Berg, 1980; Shaver and Chapin, in press) indicate they are operative in this wet tundra type as well.

As important as the study of ecosystem dynamics and their relationship to the soil-landform pattern is, it is just as important to develop a model in which these interactions are set within an extended time frame depicting the stability of soil-landform-vegetation pattern. This of course can be done only by detailed morphological (including

botanical) chemical-physical and radiometric analyses of the patterns. A considerable amount of attention has been focused on the evolution of at least the gross aspects of landforms and soils on the arctic coastal plain (Sellmann and Brown, 1973; Brown et al., 1980; Tedrow, 1962, 1969; Britton, 1958; Everett and Parkinson, 1977; Carson and Hussey, 1959). These investigations have elucidated the modifications in topography and soil development as a result of the migration of thaw lakes. Inland from the coastal plain and along the Yukon River-Prudhoe Bay haul road gradient where other forms of surface modification dominate, for example, fluviatile and eolian processes, much less is known about the permanency or evolutionary history of the grosser aspects of the landscape.

On the level of soil (vegetation) micro-landform units very little is known concerning the temporal stability of these systems (hence the temporal stability of the ecosystem as a whole). Some attempts have been made in this direction (Outcalt, 1974; Everett, 1966; Everett and Parkinson, 1977; Everett, 1980). It was noted at Prudhoe Bay (Barrow and Meade River as well) that a well-developed evolutionary pattern involving both soils and microrelief exists within, for example, low center polygon tundra such that the centers of given low center polygons may be points of extended stability (Everett, 1979) whereas the rims and troughs are undergoing a progressive change in such attributes as soil morphology, organic matter accumulation, oxidation, moisture and temperature as well as nutrient status.

In light of the above it was proposed to investigate soil-landform interactions (form and process) in selected wet tundra environments along north to south and west to east gradients (Fig. 1). The wet tundra was selected

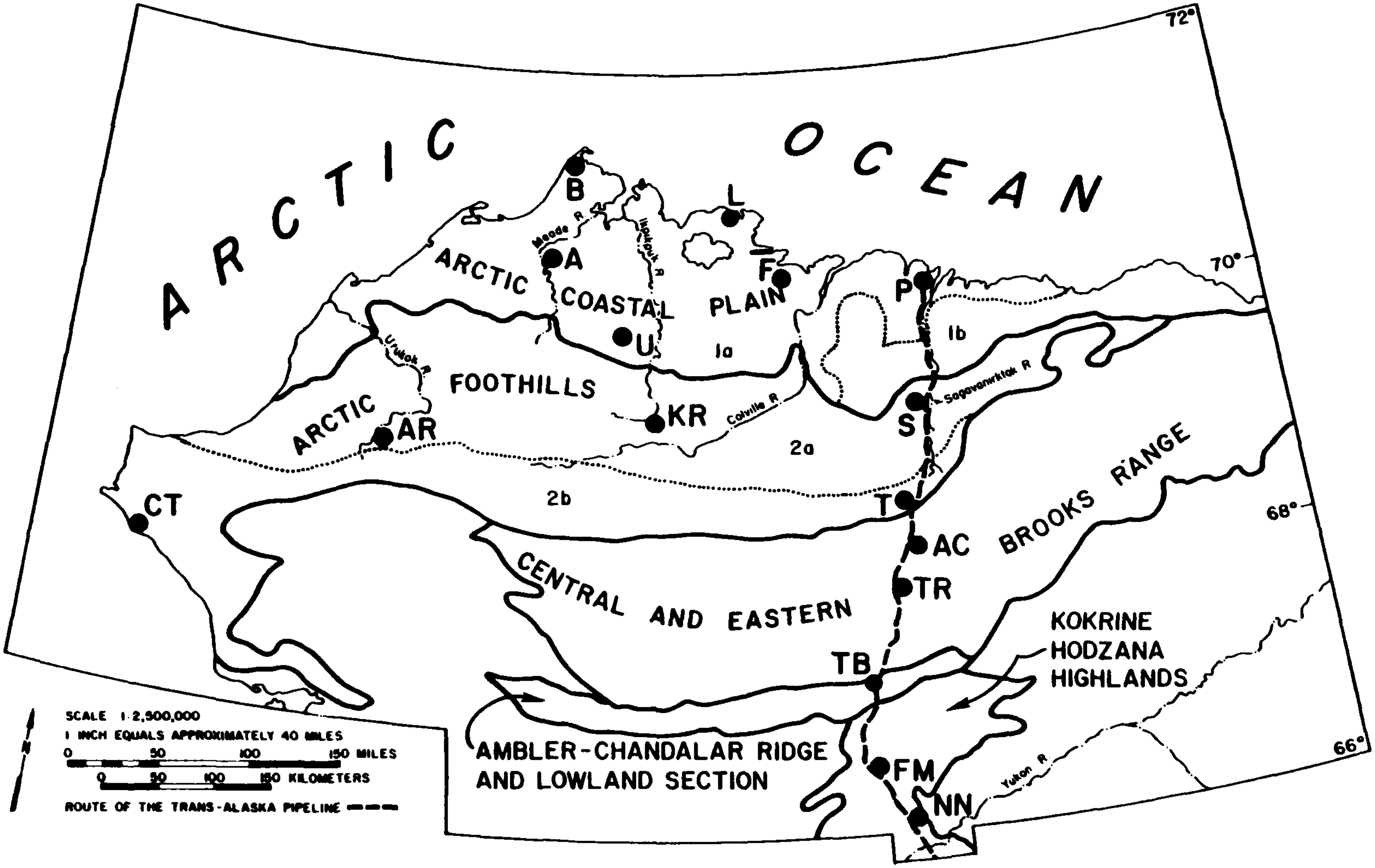


Fig. 1. Location of soil-landform and other sites in northern Alaska referred to in text. (CT) Cape Thompson; (AR) Archimedes Ridge; (KR) Knifeblade Ridge; (O) Oumalik; (A) Atkasook; (B) Barrow; (L) Lonely; (F) Fish Creek; (P) Prudhoe Bay; (S) Sagwon Uplands; (T) Toolik; (AC) Atigun Canyon; (TR) Treeline; (TB) Tramway Bar; (FM) Finger Mountain, (NN) No Name Creek.

because it is most extensive areally and thus is the largest habitat type; it is biologically the best understood environment as a result of the Tundra Biome investigations; it is potentially the most sensitive to disturbance and, it offers the most satisfactory base for circumpolar comparison of wet tundras. Because the sites were selected to typify a significant portion of a physiographic province or section, the soils landform information and map base can, if necessary, be extended to unmapped areas using conventional aerial photographic techniques or at much smaller scales on a regional basis using ERTS immagery.

Objectives:

(1) To trace the development of soils, especially those of the wet tundra, and their relationship to associated microtopography.

(2) To determine to what extent the wet tundra soils and their related microtopography are the products of a cyclic repetition of events involving vegetation succession and hydrologic changes (tussock tundra) or in the case of the very wet polygonized tundras, are the products of an evolutionary sequence leading to the abolition of the pattern and the creation of a new landform-soil association.

(3) To determine the time frame in which these processes occur and thus gain an understanding of the temporal stability of the soils and landforms along the regional gradients and within selected mesogradients.

(4) To produce a detailed series of soil-landform maps and soil characterizations for selected areas along the gradients using the techniques developed for the coastal plain tundra.

Physical Geography

Surficial and bedrock geology

The Coastal Plain Province consists of unconsolidated Quaternary deposits resting on, generally northward dipping Tertiary and older rocks. The unconsolidated materials of the coastal plain were originally described by Black (1964). They range widely in lithology, from marine and non-marine sand, silt, clay and gravel that are referred to collectively as the Gubik Formation. The thickness of these deposits is generally less than 50 m. Studies in recent years by Carter, 1981a; Williams et al., 1977; and Hopkins, 1981 have shown the Gubik Formation to be quite complex and to consist of perhaps, several formations, an eventuality anticipated by Black.

Surface deposits on the outer coastal plain where Barrow and Prudhoe Bay are situated consist of fine grained silts and clays of marine origin (Fig. 2) and represent the most recent marine transgression. The southern part of the coastal plain and northern portion of the foothills sections are mantled with silts and fine sands of both marine and continental (alluvial deposits derived from the Brooks Range) origin. South of Prudhoe Bay several outcrop areas of Tertiary conglomerates are surrounded by those deposits.

Much of the Coastal Plain Province has been subjected to one or more episodes of thaw lake activity during which the sediments have been reworked and substantial amounts of organic materials have been incorporated. Thaw lakes have been actively reworking the surface of the coastal plain for at least the last 14,000 years in the Barrow area (Brown, 1965; Brown et al., 1980) and perhaps for the last 100,000 years in the Prudhoe Bay area (Lachenbruch and Marshall, 1977). Old land surfaces (a few thousands of of years old) are thus very rare and exist only as remnants standing 1 meter

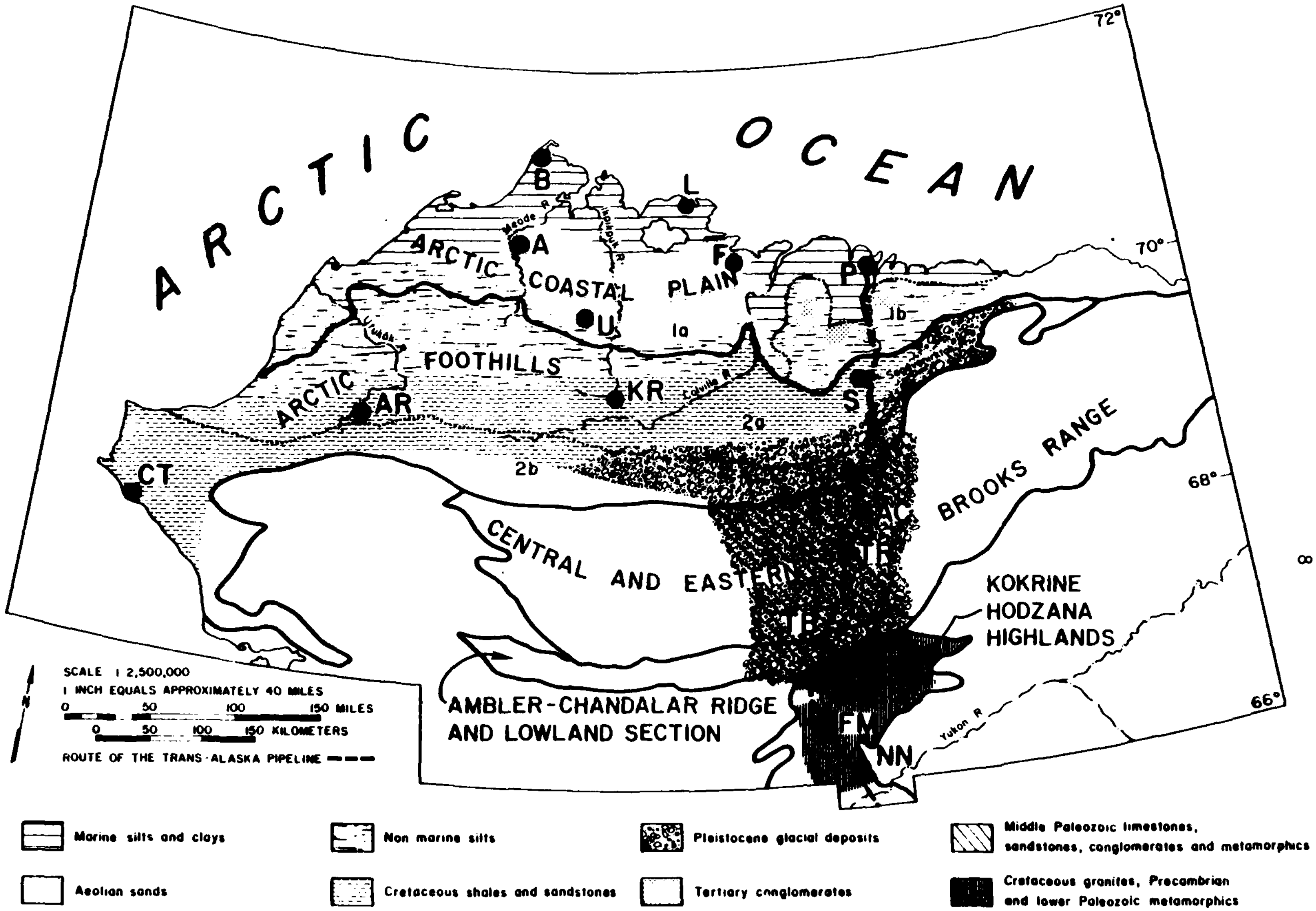


Fig. 2. Generalized distribution of major rock types in the area of soils-landform studies in northern Alaska.
Compiled from University of Alaska, (1975)

or so above the general land level and surrounded by active and/or drained thaw lake basins. On the outer elements of the coastal plain elevations are generally less than about 15 m, but rise inland reaching near 100 meters at the southern boundary of the province.

The mapping sites at Fish Creek, West Oumalik and Atkasook are within a region of sands that form the central part of the coastal plain (more than 7000 km^2, Carter, 1981b),(Fig. 2). These sediments, originally of marine origin were reworked by wind into large longitudinal dunes during late Wisconsinan time (36,000 to 12,000 years ago). The sand sheet apparently became stabilized by vegetation about 8,000 years ago (Carter, 1981). In the last 3500 years small longitudinal and parabolic dunes have formed and became stabilized (Carter, 1981b;Everett, 1979).

The Foothills Province to the south of the coastal plain consists mostly of folded shales, interbedded with sandstones, conglomerates and coal measures (Brosgé and Whittington, 1966; Chapman and Sable, 1960). Upland elevations are generally between 300 and 650 m (750 m) and valley bottoms between 150 and 300 m in the northern and southern sectors respectively of the Arctic Foothills Province. The mapped sites of Toolik, Sagwon Uplands, Knifeblade and Archimedes Ridge as well as sites at Cape Thompson and Umiat occur within the Province (Fig 2). Near the southern margin of the Foothills Province especially east of the Etivlok River glacial till, moraine and ice contact deposits mantle much of the bedrock in the major river valleys. In some cases these deposits extend to more than 90 kilometers beyond the mountain front.

The passage from the Foothills Province to the Brooks Range is marked by an abrupt increase in elevation to from between 1250 to 1900 m. Except for a narrow and discontinuous belt of Permo-Trassic, shales, limestones and sandstones and carboniferous limestones the bulk of the Brooks Range complex, especially the area transversed by the Yukon River-Prudhoe Bay haul road and the soils mapping sites, consists of Devonian rocks ranging in lithology from limestones to sandstones, shales and various grades of their metamorphic equivalents (Lawson, 1980). The entire area has been glaciated and moraine materials and ice contact deposits can be found in most of the larger valleys. In many instances these deposits have been masked or removed by post glacial processes, notably solifluction and other forms of mass movement. In some of the broader valleys, the northern part of the Atigun River Valley near Galbraith for example, stratified lacustrine deposits occur.

Two map sites are located in the Brooks Range Province, one in the Atigun River Valley (Fig. 2) where bedrock consists of well indurated Devonian age conglomerate with minor amounts of shale and sandstone. Alluvial fans, talus cones and aprons, rock glaciers and kame moraines mantle the lower valley walls. The second site (Treeline) is just to the south of the Chandalar Shelf near the headwaters of the Dietrich River. Here soliflucted materials derived mostly from the phyllite bedrock mantle the slopes.

South of the Brooks Range but still within the Arctic Mountains Province is the narrow Ambler-Chandalar Ridge and Lowland section extending from Coldfoot to the south fork of the Koyukuk River (Fig. 2). Ridge elevations are mostly below 1000 m with the lowlands 300 m or less.

A variety of bedrock types similar to those between Galbraith and the Toolik site make up the ridges. In addition some metamorphic rocks, schists and phyllites are present, together with mafic igneous bodies. The lowlands, in which the Tramway Bar site is located consist largely of sands and gravels that form terraces, together with colluvial deposits, loess and probably glacial till.

The remainder of the map sites, Finger Mountain and No Name Creek are located within the Kokrine-Hodzana Highlands. For nearly the entire distance between the Jim River near the northern boundary of the Province to the Ray River Valley near its southern edge the haul road crosses colluvial deposits. Bedrock exposed on the higher valley slopes includes Mesozoic and some upper Paleozoic Volcanics and intrusives and their metamorphic equivalents as well as extensive areas of Cretaceous granites (Kachadoorian, 1971). The lower valley slopes are composed of colluvial materials many of which show signs of solifluction. Recent alluvial deposits together with old glaciofluvial sands and gravels are common along the Jim River and some of its tributaries. Loess commonly covers the older higher elevation terraces.

The valleys of the Kanuti River, west fork of the Dall River, Fish Creek and Bonanza Creek contain silt to gravel-size alluvial deposits that are commonly overlaid by loess or colluviam. Organic rich silts occupy the swampy flood plains of Bonanza Creek and along the Kanuti River near Old Man (Lawson, 1980). Just to the south of the Kanuti flat are granitic uplands characterized by erosional remnants (tors) that attest to intense, long duration frost shattering.

As the Yukon River is approached coarse grained gravelly deposits are common on the uplands while colluvium composed of gravels and local bedrock blanket the lower parts of the slopes. Loess thickness increases near the Yukon River. In the low-lying areas thaw ponds and low centered polygons are developed.

Climate (including soil climate)

The chemical and physical processes that bring about the morphological differentiation that characterizes a given soil profile are to a very significant degree conditioned by the climate under which they take place. In the 1938 classification of soils (Baldwin et al., 1938) placed soils of the cold zone (north of 62°N latitude or the E climate zone) within the Great Soil Group of tundra soils. These soils had in common, formation under conditions of a frigid humid climate, poor drainage, gleization and mechanical disturbance and thus were placed within the Zonal Soil Order. The representation of the zonal soil was a natural soil developed on the well drained sites and reflecting in its morphology the fullest impact of climate (and vegetation). It should be pointed out that under these terms a very small percentage of soil-landforms in the tundra region would actually qualify as zonal.

In the last dozen or so years the concept of zonality in soils has given way to one in which process dominates. Nevertheless climate, and in particular, specific climatic parameters are incorporated in nearly all levels of classification.

The soil-landform sites chosen along the Yukon River-Prudhoe Bay haul road and across the Arctic Coastal Plain transect significant climatic gradients. Thus an opportunity is afforded to study the processes of soil development, in both poorly drained and well drained sites under a broad range of cold climate.

Temperature

North of the Continental Divide (foothills and coastal plain) winter temperatures are extreme, summers are cool and short and precipitation

is low. During the winter period the entire area north of the Yukon River is under the influence of cold arctic air to an elevation of 800 to 1000 m (Haugen, 1980; Haugen and Brown, 1980). In the north central portion of the coastal plain a stable winter temperature inversion occurs to between 1000 and 1500 m and keeps temperatures near -30°C (Walker et al., 1980) Western sites, Barrow and Cape Thompson for example, are not so subject to the stable inversions, or to the extreme low winter temperatures. Low winter temperatures also occur south of the Continental Divide but are less regional in character and less persistent due principally to greater topographic variability.

With the onset of spring the Arctic Front receeds north of the Divide and sites to the south come under the influence of southern frontal systems and local, orographic effects. In this region average temperatures are generally positive by May and by June are 10°C or above where they remain through August.

North of the Divide, positive air temperatures do not occur generally until June. Within the Foothills region, average summer temperatures (July and August) of 10°C or above are common. During this period the Arctic Front has moved to the northern edge of the coastal plain and the Foothills come under the influence of southern storm systems and warmer katabatic air flow from the Brooks Range.

Average summer temperatures (July and August) on the coastal plain generally do not exceed 7°C and within a narrow zone near the coast the average summer temperature is near 4°C. This zone constitutes (approximately) the litteral tundra of Cantlan (1961) and extends east-west along the northern coast of Alaska; here snowmelt may be delayed well

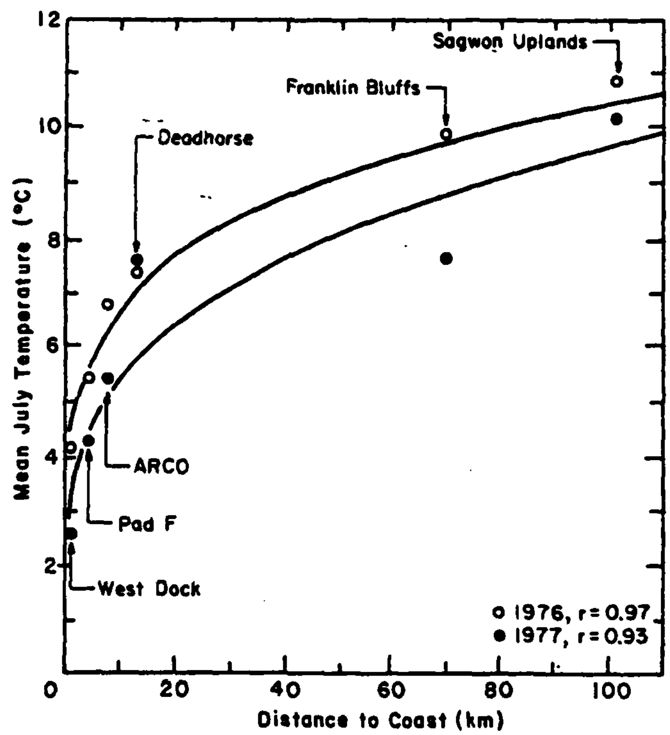


Fig. 3 . Mean July coastal-inland temperature gradient for 1976 and 1977 from Prudhoe Bay to Sagwon Uplands. From Walker et al., 1980.

into June. The pronounced summer temperature gradient that characterizes the coastal plain and Foothills Provinces is shown in Fig. 3 . Figure 4 portrays the annual temperature regime within the soil-landform study area. The temperature pattern for the region south of the Foothills is typical of a continental climate (Haugen, 1980). North of the Foothills the climate becomes increasingly maritime.

The strength of the air temperature gradient is equally impressive and more meaningful in degree days i.e., the accumulated departure of the mean daily temperature above or below $0^{o}C$. Figure 4 adapted from Haugen, 1980 illustrated the trend in thaw degree days along the Haul Road transect for the period in which the soil-landform studies were conducted. With reservation this trend can be extrapolated westward until a similar but probably less intense west to east gradient begins to interfere.

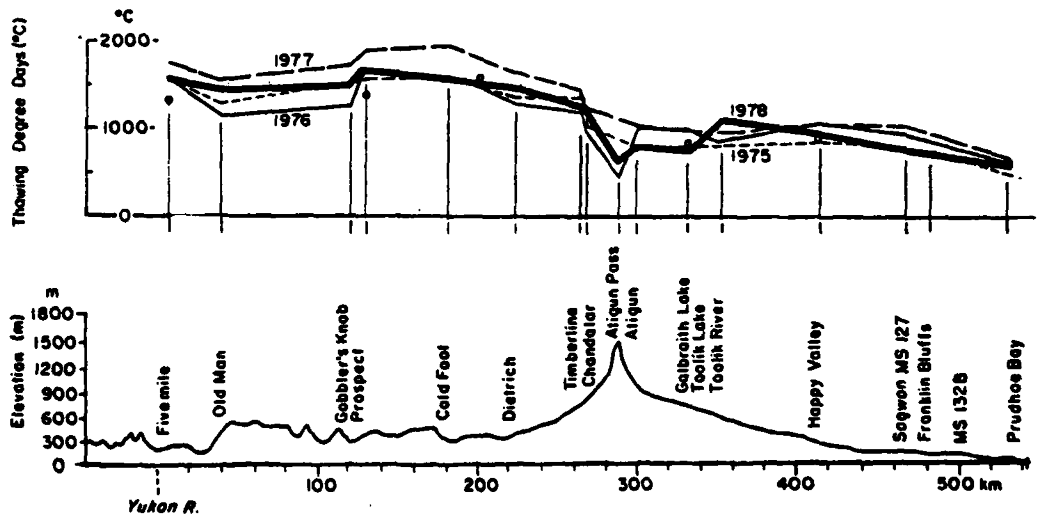


Figure 4 . Climatic transects for the Haul Road, illustrating the variation of precipitation, thawing, and freezing degree-days (^{o}C) over the transect. Small circles on the thawing and freezing degree-day cross sections indicate values obtained by averaging available data prior to 1975. Adapted from Haugen, 1980.

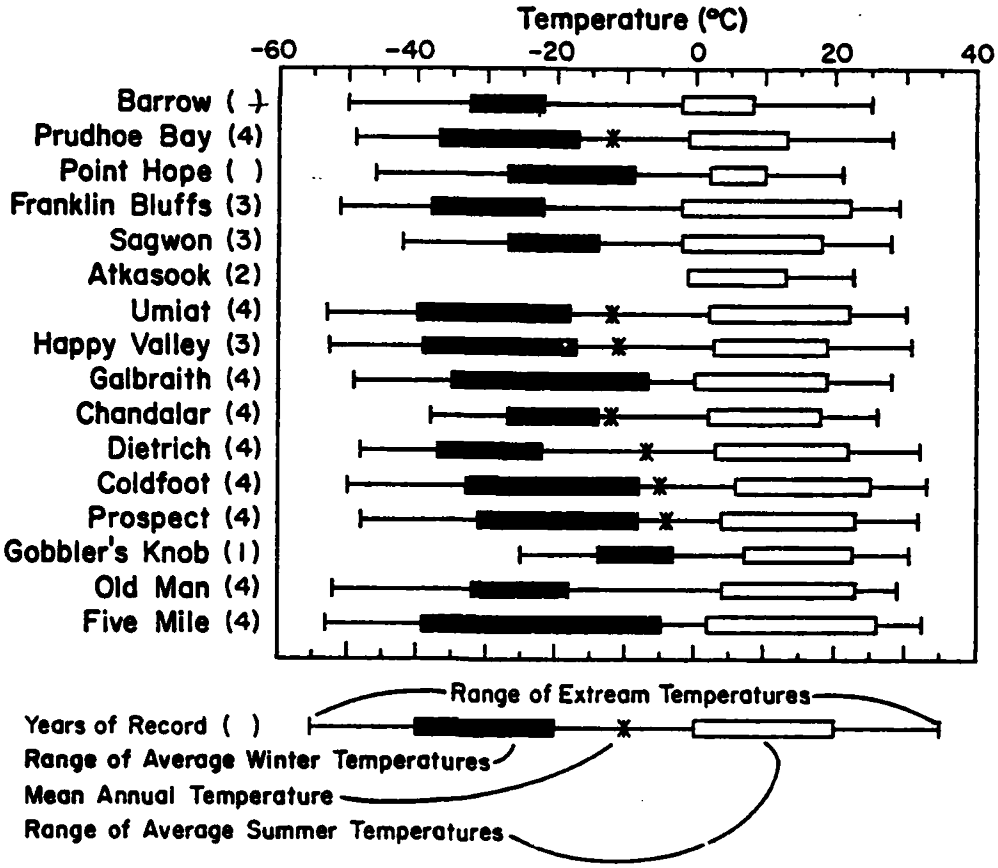


Fig. 5 . Annual temperature regimes for Haul Road stations. Mean annual temperatures are indicated by "X" on the extreme range line for stations with at least three years' continuous record. Umiat and Bettles are included for comparison. The range of the coldest and warmest monthly minimum and maximum temperatures are indicated by solid bars for winter (Dec.-Feb.) and summer (June-Aug.) for each station. Modified from Haugen (1980).

Useful as plots of air temperature thaw degree days are, they are not helpful in assessing active layer soil temperatures except in a very general way. Examples of soil temperature measurements carried out in concert with air temperature measurement are rare in the Alaskan arctic and those that are available are seldom of sufficient depth to characterize the active layer and are thus not useful in evaluating soil processes. Reliance must therefore be placed on short term or one-time measurements. Experience indicates early August soil temperatures (1 cm) in the wet and moist littoral tundra area of the coastal plain at Barrow and Prudhoe Bay is near 3°C. In the coarser textured well drained sites 10 cm temperatures in August are close to 6°C. Wet and moist soils in the Foothills have August 10 cm temperatures near 5°C. Similar sites south of the Continental Divide also have temperatures near 5°C. Well drained sites in this region have temperatures near 10°C. It must be pointed out that these values are greatly generalized and that considerable spatial and temporal variability occurs in soil temperatures because of microrelief, soil texture, vegetation cover and soil moisture as illustrated in figure 6 .

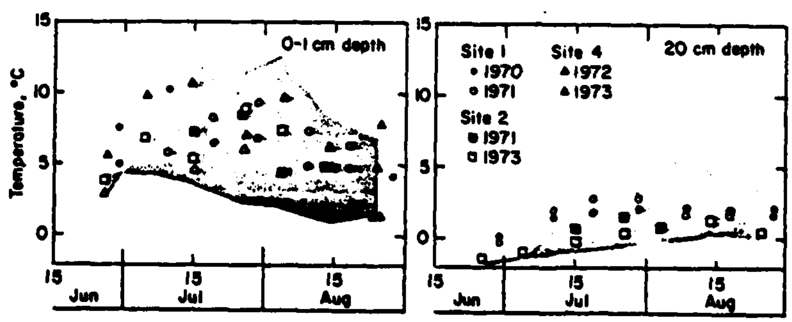


Fig. 6. Ten-day mean soil temperatures at the Biome research area as measured during 1970-73 and simulated for the extreme years during 1960-73. The shaded area represents the range of the simulated soil temperatures for the warmest year, 1968, and the coldest year, 1969. After Dingman et al., 1980.

The seasonal progression of air and soil temperature shown in Fig. 7 for Baker Lake Northwest Terrirory is probably generally applicable to the more southern portions of the Foothills section of Alaska.

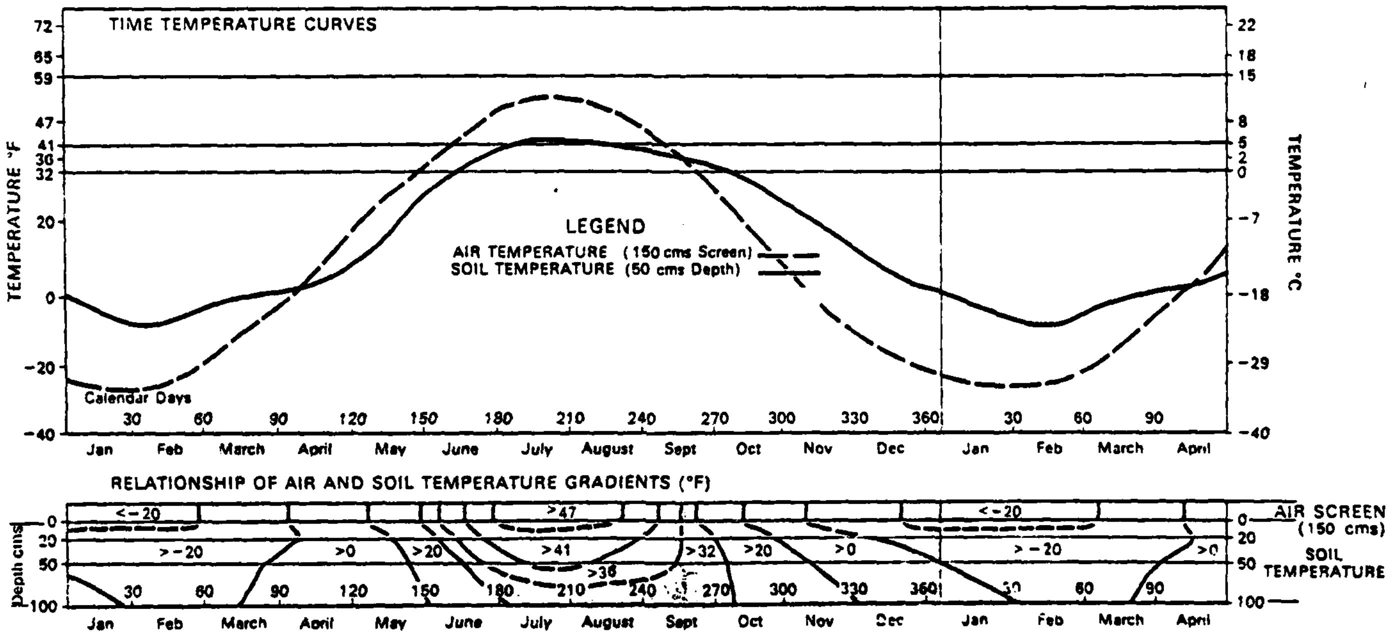


Fig. 7. Seasonal progression of air and soil temperatures from a Canadian tundra site (Baker Lake NWT). Modified from Clayton *et al.*, 1977.

Precipitation

Haugen and Brown (1980) have shown that significant differences in precipitation do exist from north to south along the haul road transect but the trend is not as clearly developed as for temperature. In general there is an increase in total precipitation from the coast (170 mm[1)] at Barrow; 148 mm[1)] at Oliktok; 203 mm[2)] at Prudhoe Bay) to 267 mm near the Toolik site

1) Measured total 1941-1970 of 124 mm adjusted for trace precipitation (X1.1) Brown *et al*. (1968).
2) 2 years data (Wyoming gage).

in the Foothills section. To the west at Umiat is 157 mm. This value can probably be extrapolated to the Knifeblade Ridge area. A similar trend toward increased precipitation inland has been described for the Barrow area by Clebsch and Shanks (1968). The increased inland precipitation especially in the summer months is due in part to increased presence of weak frontal systems and orographic thunderstorms that drift from the Brooks Range northward. The percentage of summer precipitation in liquid form also increases inland ranging from about 36 percent at Prudhoe to 55 percent at the Toolik site. The Cape Thompson site is more akin to the Foothills sites in terms of precipitation (244 mm) because of the greater impact of frontal systems from the southwest.

The greatest percentage of summer precipitation at the coastal plain sites occurs in the form of mists or very light rain (nearly 71 percent of that at Barrow is < 3 mm (Wise and Searby, 1977). Heavy rains do occur but are much more common in the Foothills, Umiat for example recorded 107.5 mm on 13 June 1980 (NOAA, 1980).

Total precipitation south of the Continental Divide in both frontal and orographic. There is much less regional uniformity in total values with higher elevations receiving more than lower areas (Haugen, 1980).

Winter precipitation appears to occur in a pattern reversed to that in the summer, i.e., decreasing away from the coast. It is nearly all as snow. North of the Continental Divide most of the snow falls during September and October while the still open water of the Beaufort Sea provides a moisture source (Walker _et al_., 1980). Total September through May snowfall at Prudhoe Bay amounted to 137 mm water equivalent in 1976-77.

This translates to a winter snow cover of between 30 and 40 cm (Benson et al., 1975; Everett and Parkinson, 1977). In the Foothills snowfall accounts for between 70 and 86 mm water equivalent (Haugen, 1980). The small amount of information on the snow pack thickness in the foothills is about the same as that of the coastal plain (Everett, unpublished). South of the Continental Divide snowfall water equivalent seems to range between 118 and 180 mm with a snow pack thickness of 40 to 90 cm. At Cape Thompson the winter snow pack appears to be similar in thickness to that at Barrow and Prudhoe Bay.

The relatively low total precipitation, especially north of the Continental Divide, is extremely effective in maintaining high soil moisture levels. There are several reasons for this. (1) The flat terrain of the coastal plain restricts rapid runoff, (2) the shallow active layer presents vertical movement of water, (3) relative humidity is high and evaporation low (at the coastal plain), mosses, particularly species belonging to the genus Sphagnum are very effective in absorbing and holding moisture and together with the shallow active layer contribute to the maintenance of high soil moisture levels in most Foothills soils.

The degree to which these saturated or in some cases supersaturated soils are anoxic is a matter of special interest with regard to the affectiveness of physical, chemical, and biochemical decomposition and synthesis in these soils and to the question of nutrient cycling in general. Answers at this time are inconclusive. Many of the deeper rooted plants adapted to the wet soils depend upon subareally derived oxygen for root respiration. Relatively high oxygen levels have been measured in some microtopographic depressions near the Sagwon site in the Foothills

(A. Linkins, unpublished data). Presumably this is due to water movement within the active layer and may be a general phenomenon within the tussock tundra of the Fooshills Province.

Soil moisture within the organic horizons of some of the Coastal Plain soils are well over 1000% on a weight basis. Soil moisture of a particular site depends upon microtopographic setting and the texture (water holding capacity). For the organic soil horizons a value of 500% (d.w.b.) is probably close to the average for sites south of the coastal plain with 250% for coastal plain soils. Very much lower values are recorded for well drained soils (40 to 100% d.w.b.) Walker (personal communication).

In all but the wettest soils (those with water table of or above the surface throughout the thaw season it is probable that the upper part of the soil becomes unsaturated for some or all of the summer. This zone is usually confined to the upper 10 cm and constitutes the area of maximum biochemical activity. The range in soil moisture for an area of polygonized Coastal Plain tundra is shown in Figure 8 .

Table 1 summarizes some of the more important (from the standpoint of soil formation) climatic variables within the major physiographic divisions of northern Alaska traversed by the Yukon River-Prudhoe Bay Haul Road.

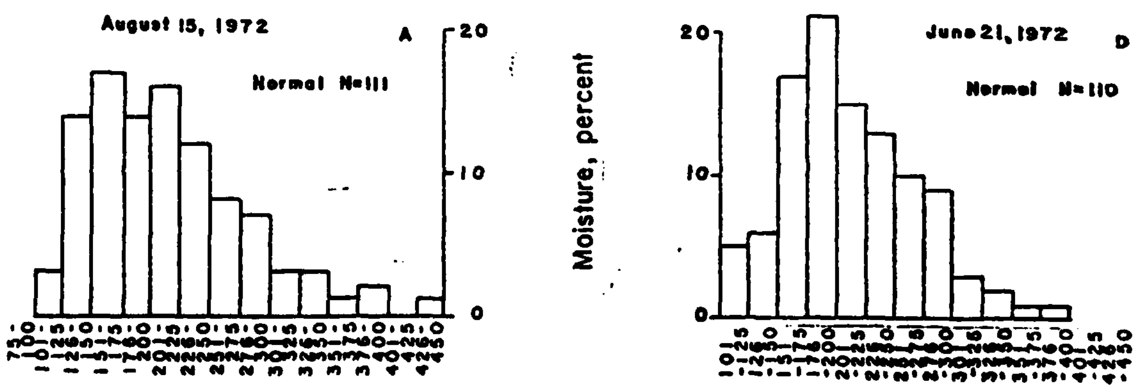


Fig. 8 . Soil moisture distribution in polygonized tundra, Prudhoe Bay, Alaska.

Table 1

Range in some selected climatic variables derived from stations along the Yukon River-Prudhoe Bay Haul Road.

	Interior	*Brooks Range*	*Arctic Foothills*	*Arctic Coastal Plain*
Degree-day totals (°C)				
Thawing	1182-1904	453-1189	760-1125	318-897
Thaw season				
Length of thaw (days)	123-168	87-131	104-139	91-128
Starting date	18 Apr-1 Jun	3 May-10 Jun	18 May-27 Jun	25 May-9 Jul
Precipitation (mm)				
Frozen	NA	57-181	87-110	125-142
Unfrozen	84-367	117-292	52-157	58-81
Total annual	168-445	295-450	140-267	183-223
Temperature (°C)				
Mean annual	-6.9 to -3.7	-6.9 to -5.9	-11.1 to -9.0	-12.8 to -10.6
Mean annual diurnal range	12.8 to 14.6	10.8 to 12.6	7.6 to 11.6	7.2 to 9.6
Annual temp range (extreme low-high)	-53.3 to +33.0	-37.8 to +26.1	-53.3 to +30.0	-50.6 to +28.9

Adapted from Haugen (1980).

Soils

Overview:

The soils of northern Alaska have developed under a cold temperature regime on parent materials that are largely fine grained and at or near saturation throughout the thaw period. Under such conditions biological and chemical transformations are slow and soil horizons, the results of these processes, are poorly developed. Also, they are subject to physical dislocation as a result of freeze-thaw processes.

Within the Tundra and Taiga regions of Alaska soils fall mostly within four taxonomic orders (Soil Survey Staff, 1975), Entisols, Inceptisols, Mollisols, and Histosols. The relative percentages of these orders within the study area are shown in Table 2 .

Soils belonging to the order Entisols are mineral in composition and, with few exceptions, contain little or no organic material. Recognizable morphological characteristics are absent or only poorly defined. Entisols are for the most part relatively well drained. They are confined to geologically young, often unstable surfaces or have parent materials generally lacking weatherable minerals, e.g., river bars and terraces, sand dunes, marine beaches and alluvial fans. Such surfaces commonly support an incomplete cover of vegetation that contributes little organic matter to the soil. Entisols (Cryorthents especially) are common within the mountain areas.

Soils belonging to the order Inceptisols comprise two-thirds to more than three quarters of the soils within the Arctic Coastal Plain and Foothills Provinces and the Taiga as it is restricted in this report.

Table 2.

Area occupied by principal soil orders in northern Alaska study area with hectares and their % of the total area.

Province	Total ha	Entisols[1]	% of Total	Inceptisols[1]	% of Total	Histosols	% of Total	Mollisols[1]	% of Total
Arctic Coastal Plain	4.98×10^{6}	6.01×10^{5}	12	7.99×10^{6}	65	5.81×10^{5}	12	5.31×10^{5}	11
Foothills	1.27×10^{7}	9.10×10^{5}	7	8.87×10^{6}	70	2.56×10^{5}	2	2.39×10^{6}	19
Taiga[2]	3.40×10^{7}	4.04×10^{6}	12	2.62×10^{7}	77	2.48×10^{6}	7	1.60×10^{5}	<.5

1) Includes only Pergelic and Lithic subgroups

2) Includes only the Interior Alaskan Lowlands and Interior Alaskan Highlands, Data source Rieger *et al*. (1979).

These soils occupy nearly the entire range of landscape positions. The presence of permafrost which restricts vertical drainage together with the generally fine texture of the parent materials contribute to the poorly or very poorly drained character of many of the Inceptisols, in particular those belonging to the taxonomic great group of Cryaquepts, the cold (Cry), wet (aqu) Inceptisols (ept). In such soils maximum summer thaw seldom exceeds 50 cm (as little as 20 cm on the Coastal Plain). Low oxygen levels are associated with the Cryaquepts, and grey and blue grey (Glei) colors characterize the lower parts of the soil profile. Such soils comprise about 16% of the Arctic Coastal Plain Inceptisols and 23 and 17% of the Inceptisols of the Foothills and Taiga respectively.

In areas where free soil water is at or somewhat above the surface or where Sphagnum moss is a major component of the vegetation the surface horizon of the Cryaquepts may be highly organic. When organic matter thickness reaches 20 cm (and the organic carbon content is at least 12%) the soil is said to have a histic epipedon (Soil Survey Staff, 1975). On the Coastal Plain 19% of the Inceptisols are designated as Histic Pergelic (term denoting the presence of permafrost) Cryaquepts. If the Histic part of the Ruptic (meaning interrupted) Histic Cryaquepts is added the percentage is 21.5%. In the Foothills Province some 63% of the Inceptisols are Histic Pergelic Cryaquepts (66% if the Ruptic Histic soils are included). Only 5% of the Inceptisols of the Taiga have Histic epipedons. Ruptic-Histic Pergelic Cryaquepts are essentially absent from this region.

By far the largest percentage of well drained Inceptisols occur in the Taiga region of the study area (32%). These soils are developed on

older (pre-Holocene) deposits such as high level terraces adjacent to the larger rivers and kame deposits. Profile differentiation is generally poor, however distinct A, B, and C horizons occur and in some cases the solum horizons can be subdivided. The soils are classified as Cryochrepts (the majority) and Cryumprepts. These soils have many podzolic characteristics, particularly the development of a bleached E horizon (A2) and iron or iron humus concentrations within the B horizons. A full discussion of such soils is presented on pages 330 through 347.

Within the Foothills only about 5% of the Inceptisols are included within the well drained Cryochrepts and Cryumbrepts and these occurring mostly on the sandstone outcrops in the more southern parts of the Foothills (see section on Knifeblade and Archimedes Ridges).

On the coastal plain Cryochrepts and Cryumbrepts occupy < 0.1% of the land surface, commonly associated with Pingos (Everett, 1980; Everett and Parkinson, 1977) or ancient marine beaches such as the ones at Barrow (Tedrow and Hill, 1955).

A third soil order with significant representation within the Arctic Coastal Plain and Foothills Provinces is that of the Mollisols. These dark, base rich mineral soils occupy sites with poor to moderate internal drainage. Typically they appear to have evolved in the course of drainage of Histic Pergelic Cryaquepts (Everett, 1979). On the Arctic Coastal Plain they form regular associations with Histic Pergelic Cryaquepts where the Mollisols (Cryaquolls) commonly occupy the rims of low centered polygons. Cryoborolls occur on some pingos in the Prudhoe Bay region where carbonates are abundant. These soils represent the base rich counterpart of the Cryumbrepts which are common west of the Colville River. Mollisols are not a significant component of the Taiga (Table 2).

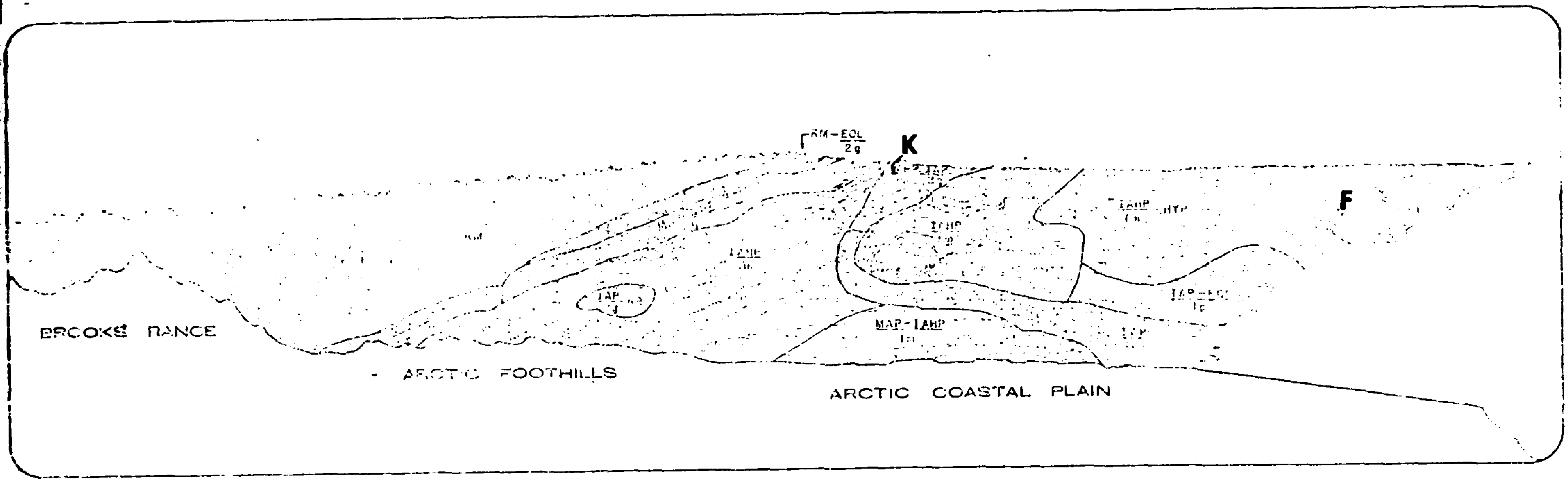


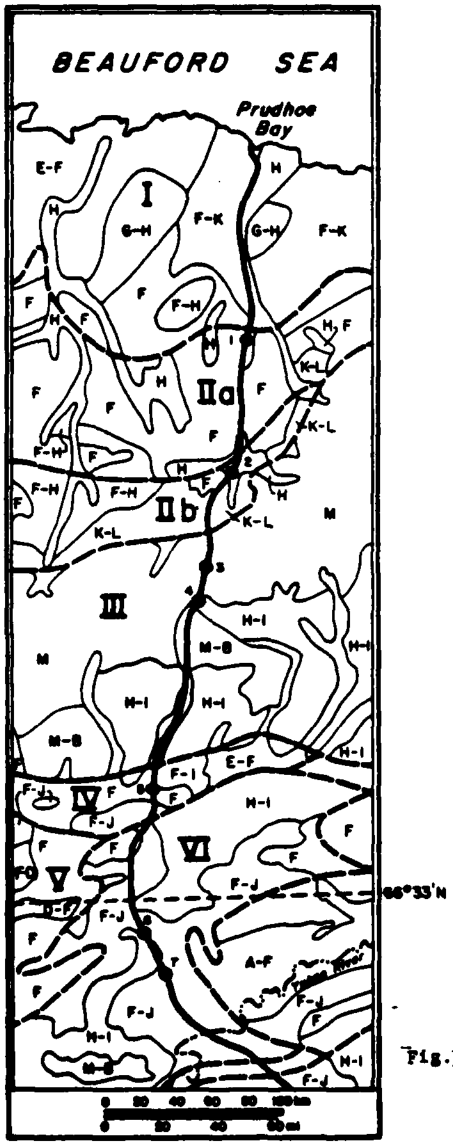
Fig. 9. Distribution of the principal soil associations within a portion of the Arctic Coastal Plain, Arctic Foothills and Brooks Range physiographic provinces. The section pictured encompasses the area inland between the Colville delta 150°W longitude and 152°45'W longitude. RM, rock-land; EOL, well drained grey soils, shallow bedrock; EQP, well drained sandy soils; IAP, poorly drained; IAHP, poorly drained soils with peaty surface layer; MAP poorly drained soils with dark, nonacid upper layer; MBP, well drained soils with dark nonacid upper layer; HYP, poorly drained fibrous peat. (K) Knifeblade Ridge site;(F) Fish Creek site. Modified from University of Alaska (1975).

The distribution of some of the broad associations of Entisols, Inceptisols, and Mollisols in an area north of the Brooks Range are shown in Fig. 9 .

Histosols form a significant component of the soils of northern Alaska. These soils have a surface organic horizon greater than 40 cm in thickness which represents the accumulation of organic matter under relatively stable waterlogged conditions spanning the last 4000 to 5000 years on the coastal plain and perhaps the last 10,000 to 14,000 years in the Taiga (Everett, 1979, D. Hopkins, personal communication). On the coastal plain Histosols are common to the centers of low centered polygons and are thus associated with Mollisols (Cryaquolls). The latter in some cases having been derived from Histosols that were uplifted in the course of polygon expansion (Everett, 1979). Any of three states of decomposition ranging from nearly undecomposed to highly decomposed are recognized and form the basis for classification at the suborder level.

Within the Foothills region Histosols occupy a small percent of the total area (Table 2). Because the area is essentially all in slope and unstable, Histosols are found generally in polygonized alluvial deposits of some of the larger streams. This situation carries over into the Taiga where the majority of Histosols are to be found in broad alluvial valleys or in peat plateaus associated with bog meadows (see Tramway Bar site pg. 221).

The following sections seek to present in detail the pattern of soils and landforms in an area(s) representative of the broader physiographic region in which it is located (Fig. 10).



__Physiographic Divisions__

I	Arctic Coastal Plain
II	Arctic Foothills
	a. northern section
	b. southern section
III	Central and Eastern Brooks Range
IV	Ambler-Chandalar Ridge and Lowland Section
V	Kanuti Flats
VI	Kokrine - Hodzana Highlands

__Soils__

(A)	EFT	Well drained soils in stratified materials on floodplains and low terraces
(B)	EOL	Well drained grey soils; shallow bedrock
(C)	EOP	Well drained loamy or gravelly grey soils; deep permafrost table
(D)	EOT	Well drained loamy or gravelly grey soils
(E)	HYP	Poorly drained fibrous peat; shallow permafrost table
(F)	IAHP	Poorly drained soils with peaty surface layer shallow permafrost table
(G)	IARHP	Poorly drained soils with many frost scars; shallow permafrost table
(H)	IAP	Poorly drained soils; shallow to deep permafrost table
(I)	ICP	Well drained thin brown soils; deep permafrost table
(J)	ICT	Well drained brown soils; nonacid
(K)	MAP	Poorly drained soils with dark, nonacid upper layer; shallow to deep permafrost table
(L)	MBP	Well drained soils with dark, nonacid upper layer; deep permafrost table
(M)	RM	Very steep rocky or ice-covered land

__Map Areas__

1	Sagwon
2	Toolik
3	Atigun
4	Treeline
5	Tramway Bar
6	Finger Mountain
7	No Name Creek

Fig.10. Soils of the Yukon River-Prudhoe Bay haul road and major physiographic regions traversed. Areas mapped under ARO sponsorship are indicated. (Modified from University of Alaska, 1975 and Wahrhaftig, 1965).

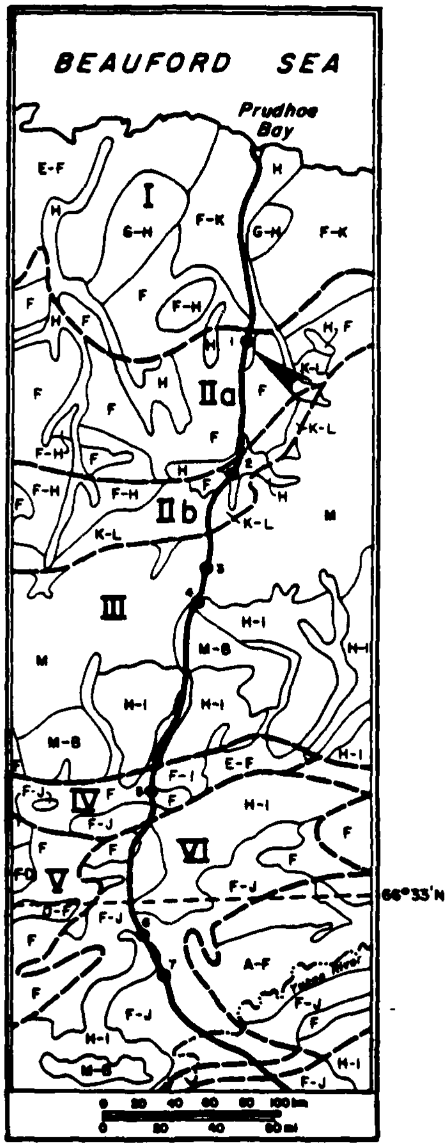


Fig. 11. Location map showing position of Sagwon uplands site (1) with respect to generalized soils and physiographic boundaries. Refer to Fig. 10.

Physical Geography

Geology

The Sagwon upland area is underlain by northward dipping, poorly consolidated conglomerates, sandstones and siltstones of the Tertiary Sagavanirktok formation (Ferrains, 1971). Thin interbedded coal is exposed in a stream cut in the map area. Immediately north of the map area unconsolidated quartz-rich gravelly materials are exposed on

SOIL-LANDFORM MAP
Mile 293 to Mile 295 T.A.P.S. Haul Road.

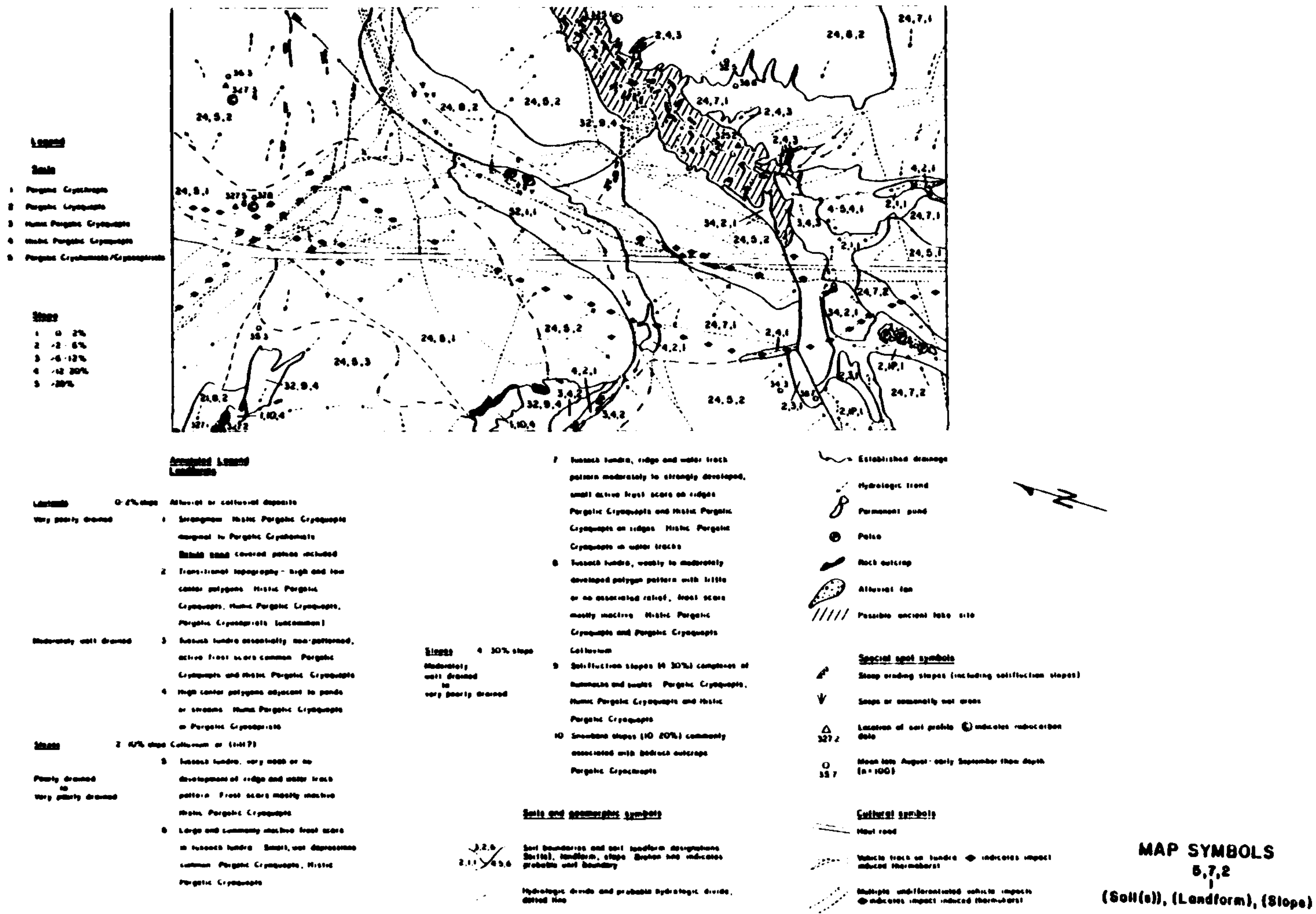


Figure 12.

some rounded hills. With the exception of a few conglomeratic sandstone outcrops fine sandy loam or loam textured mineral material occurs beneath the organic rich tundra.

Topography

The map area is a gently rolling upland, part of the White Hills physiographic province of Wahrhaftig (1965). Local relief is generally less than 65 m . The region rises abruptly 270 m from an incursion of the coastal plain to the north. Most slopes are long and quite uniform in character except where headward eroding valleys tributary to the Sagavanirktok River have cut into the upland. A low south facing cuesta - like ridge of conglomeratic sandstone occurs at the southern extremity of the map area.

Principal drainages in the area have shallow cross-sections with generally ill-defined channels or flow paths. They head in broad poorly-drained interfluve areas where peat plateaus (Palsas) are common. To the east, a deeply incised stream tributary to the Sagavanirktok River is eroding into one of the shallow channels, apparently the site of a former lake (see Fig.16)exposing organic materials, and bedded lake sediments overlying sediments of the Sagavanirktok formation including a thin coal bed. Several of the upland streams drain west to a well-defined north trending stream that eventually becomes tributary to the Sagavanirktok River.

In several areas the hillslopes display subtle drainageways or water-tracks generally parallel to the local slope. These features, often difficult to see, are marked by unique vegetation. Some of these drainage

ways are incised where they enter a major drainage and in at least one case a small alluvial fan marks the outlet. Field evidence suggests some of these water-tracks are the result of random, parallel erosion on homogeneous sediments and they are probably quite old (older than 5000 years). Other slopes display a slope-normal and parallel array of water-tracks. The subtle secondary array of slope parallel depressions produce an orthogonal polygonal pattern on the slope. This suggests a system of weakly expressed ice wedge polygons is developed on the slopes and that in some cases thermal erosion has accentuated the slope-parallel elements. Because not all water-tracks can be linked to slope parallel features it is suggested that both kinds of development have occurred.

Solifluction lobes, and hummock and depression topography occur on steep slopes near some stream heads and areas adjacent to outcrops where surface (and subsurface) water flow is concentrated. Two large, crescentric nivation and/or mudflow basins occur just beyond the map area and solifluction forms are prominent on the debris slopes downslope from the headwalls.

Permafrost

The entire area is underlain by permafrost. Inferences made from large polygonal markings (water tracks) on slopes together with the extreme thermokarst associated with old tractor trails, and a limited amount of shallow coring, suggest the area contains substantial amounts of underground ice in the form of wedges. Peat plateaus (Palsas) in the broad shallow drainages and interfluve areas indicate considerable tabular segregation ice masses up to 8 m or more in plan dimension.

Active layer thickness measured in late August - early September show permafrost to be at an average of 36 cm (33-39 cm) in the upland tussock areas, ~ 70% of the map area. In the wet interfluves and broad drainages permafrost ranges to 35 cm. Beneath the well insulated peat plateaus ice or ice rich mineral soil is encountered at 20 cm or less.

Vegetation

In general, the area is typical upland tussock tundra. The long relatively uniform slopes are characterized by well developed (up to 30 cm high) tussocks of *Eriophorum vaginatum* and associated *Ledum palustre*, variable amounts of *Salix* spp. and *Betula exilis* (Fig.13). There is a prominent component of cryptogams including *Sphagnum* spp. and *Salix* spp., which appear to be especially important on the east-facing slopes and in water-tracks where it is associated with *Eriophorum vaginatum*, *Carex aquatilis* and *Sphagnum* spp.

Active and static frost scars may occupy up to 50% of the surface on tussock slopes. While many frost scars generally lack vascular plants, except for *Petasites* sp.,and presumably are active, many more, perhaps over 50% have nearly complete coverings of algal mats and varying amounts of cryptogams.

Wet solifluction slopes are dominated by *Eriophorum* spp.; *Carex aquatilis* and *Carex* spp. with varying amounts of *Salix* spp. and *Betula exilis*. Very wet drainage ways have *Carex aquatilis*. *Betula* thickets with moss ground cover characterize the peat plateaus (Palsas).

Dry sites including outcrops and high centered polygons are characterized by Salix spp.; Salix alaxensis, Salix phlebophylla, Arctostaphylos sp., Betula exilis, cryptogams, grasses and an assortment of flowering annuals. A detailed survey and map of the vegetation in the area is given in Webber et al. (1978).

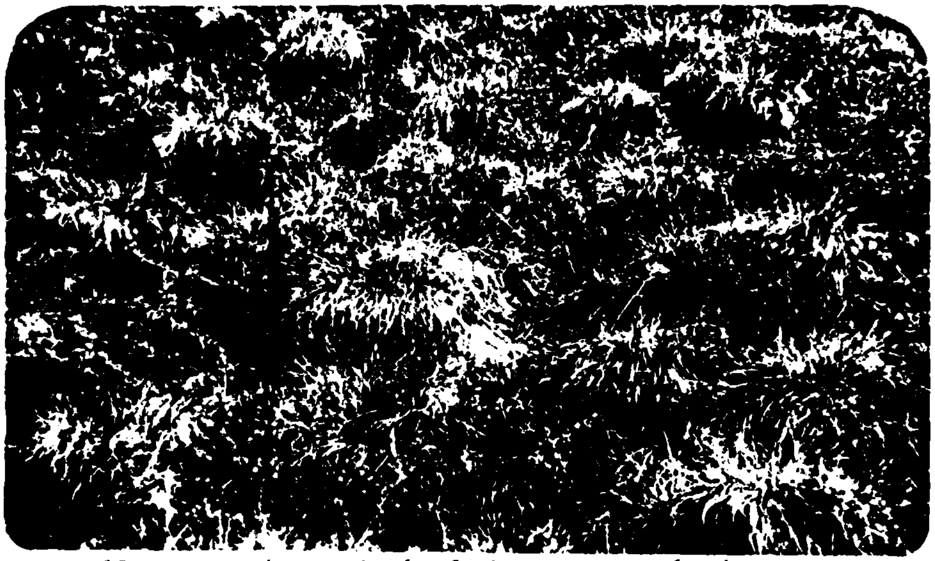


Figure 13. Tussocks typical of the Sagwon Upland map area.

Soils

Most of the soils encountered in the map area belong to the soil order Intisols and the sub-order Aquepts i.e., poorly drained, wet, weakly horizonted soils. The two most prominent great groups of soils within the Aquepts are Pergelic Cryaquepts and Histic Pergelic Cryaquepts (Fig. 14). The first are dark colored, usually mottled mineral soils with variable thickness up to 20 cm of overlying organic materials. The second group are similar to the first but have between 20 and 40 cm of overlying organic materials. The adjective Pergelic and the prefix Cry attached to all soil taxa defined in the study area refer to the presence of permafrost (adj.) and the cold soil temperature (Cry referring to annual soil temperature between 0 and 8°C). The association of Pergelic

Cryaquepts and Histic Pergelic Cryaquepts occurs in areas of tussock-frost scar tundra.

Strongly sloping areas with solifluction features have complexes of Pergelic Cryaquepts, Histic Pergelic Cryaquepts, Humic(?) Pergelic Cryaquepts (soils whose organic rich surface horizons have been oxidized by virtue of better drainage in solifluction hummocks and whose exchange complex is at least 50% saturated with bases i.e., Ca, Mg) and organic soils (Histosols) with greater than 40 cm of organic material peat overlying mineral soil.

Lowland areas are dominated by Histic Pergelic Cryaquepts with lesser amounts of Pergelic Cryohemists (moderately decomposed organic soils) and Pergelic Cryaquepts. In most active drainages the organic soils that do occur only just meet the 40 cm organic thickness requirement.

Peat plateaus (Palsas) are in many areas sites of organic soils. In the Sagwon area only a thin 20 cm or less organic horizon occurs above clear ice or high ice mineral soil. These sites were not drilled and it is possible that significant thickness or organic material occur at depth.

Relatively well-drained soils occur in two different topographic sites; raised centered polygons adjacent to incised drainage and gravelly areas associated with outcrops (Fig.14). Soils of the raised centered polygons are mostly Humic Pergelic Cryaquepts, or if the base saturation is less than 50% they are Sapro-Histic Pergelic Cryaquepts (i.e., Histic Pergelic Cryaquepts whose organic horizon has been highly oxidized due to better drainage in the process of thermokarst and thermal erosion that produced the high centered form (Everett, 1979)).

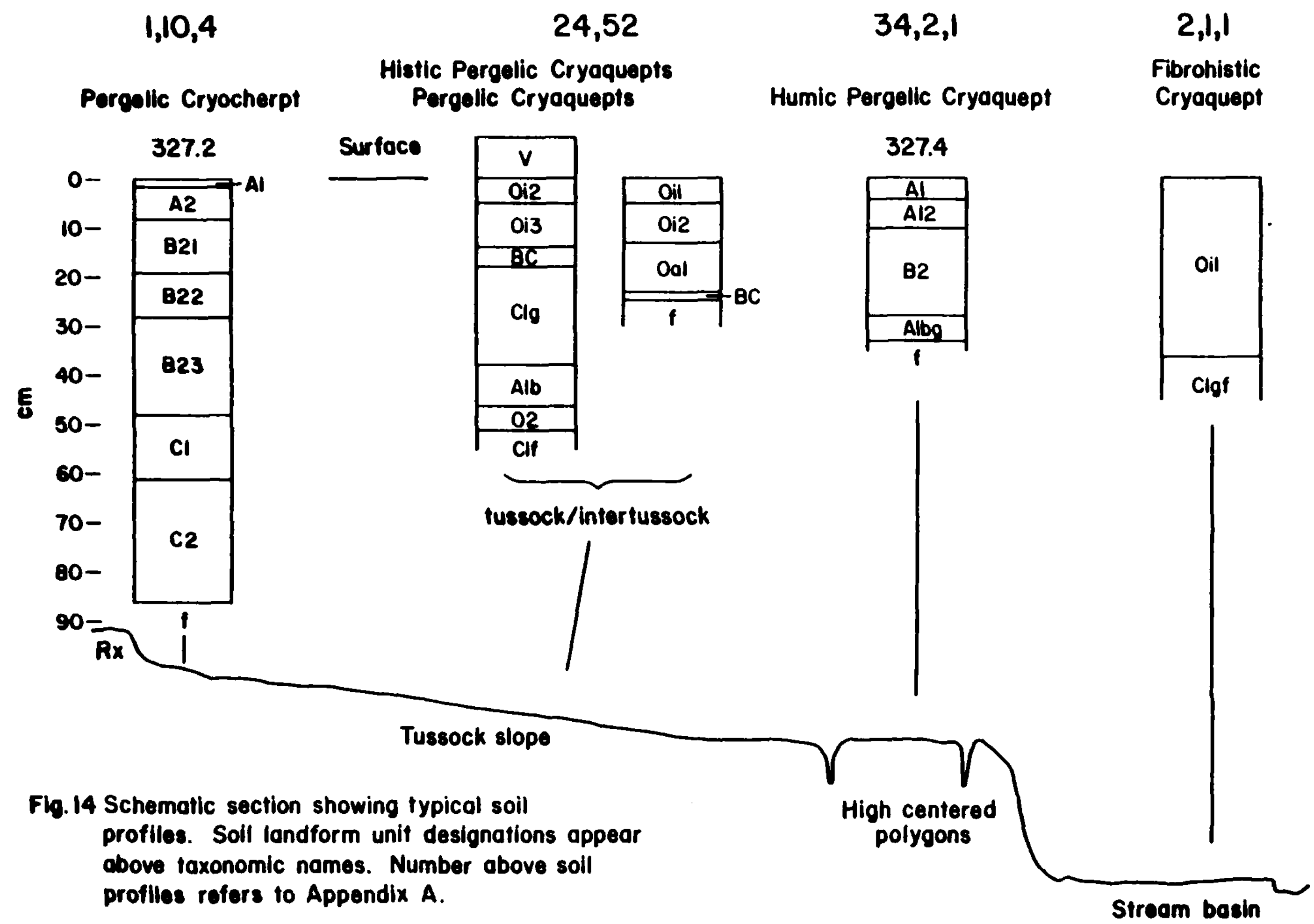


Fig. 14 Schematic section showing typical soil profiles. Soil landform unit designations appear above taxonomic names. Number above soil profiles refers to Appendix A.

Outcrop areas and their associated coarse grained relatively well-drained soils are very restricted in the map area (Fig. 12) but more extensive in the adjacent areas. The soils are classified as Pergelic Cryochrepts (although further study may place them within the order Entisols. They display many features of leaching and soil horizon differentiation. These features strengthen to the south along the haul road suggesting a transition to the Spodosols, see pg. 335. The Cryochrepts of exposed portions commonly have an incomplete cover of vegetation that displays xeric characteristics and a partial lag gravel surface. In less exposed areas (snow bank positions) plant cover is usually complete and evergreen varieties (e.g., *Empetrum nigrum*) are common. It is likely that such plants supply organic acids that together with excess water in spring are important in leaching the soil profile and in translocating clays and iron within the soil. Areas where Cryochrepts are most common are also those most sought for quarries.

Landscape Evolution

The Sagwon site is well beyond the limits of any known Pleistocene age ice advance (Hamilton and Porter, 1975) and was not subjected to marine inundation during interglacial periods. Therefore surface deposits are the result of weathering of the sandy poorly consolidated Tertiary sediments and the enmixture of loess (silts and clays) derived from the nearby Sagavanirktok River channel.

Considerable climatic fluctuation during the Pleistocene has undoubtedly affected the Sagwon upland area as a consequence of its proximity to the coastal plain. Cold periods during which cryoturbation

and fluviatile erosion were reduced in intensity with respect to the present alternated with warmer interglacial periods in which both processes may have been more active than present. It was probably during the warmer episodes that much of the landscape sculpturing and colluviation took place.

Data generated in the course of soil and landform mapping indicate that organic matter accumulation in a tussock tundra environment was taking place nearly 9000 years B.P. on a landscape much the same as today (Figure 15). Its slow accreation and intermittent burial trough frost scar activity occurred to at least 5000 years B.P., an age common to materials just below the late summer active layer in many areas of the north slope.

What possibly was a shallow lake developed in a lowland area, probably a former stream channel, in the southeast part of the map area (Fig. 16). Lateral cutting by the Sagavanirktok River permitted active stream erosion into the site and exposed the section shown in Fig. 5. The lowermost part of the fill appears to have been water worked sands and gravels (and coal) from the Sagavanirktok formation. The overlying weakly laminated finer grain deposits suggest a gradual transition to a shallow pond that received fine sediments and organic debris. At about 5000 years B.P. the pond became sufficiently shallow that sedge peat began to accumulate. One major interruption occurred in which colluvial materials, including loess(?), covered the sedge meadow- a meadow probably like those that exist today in the headwater areas of streams and at divides in which Betula and Salix are significant components of the

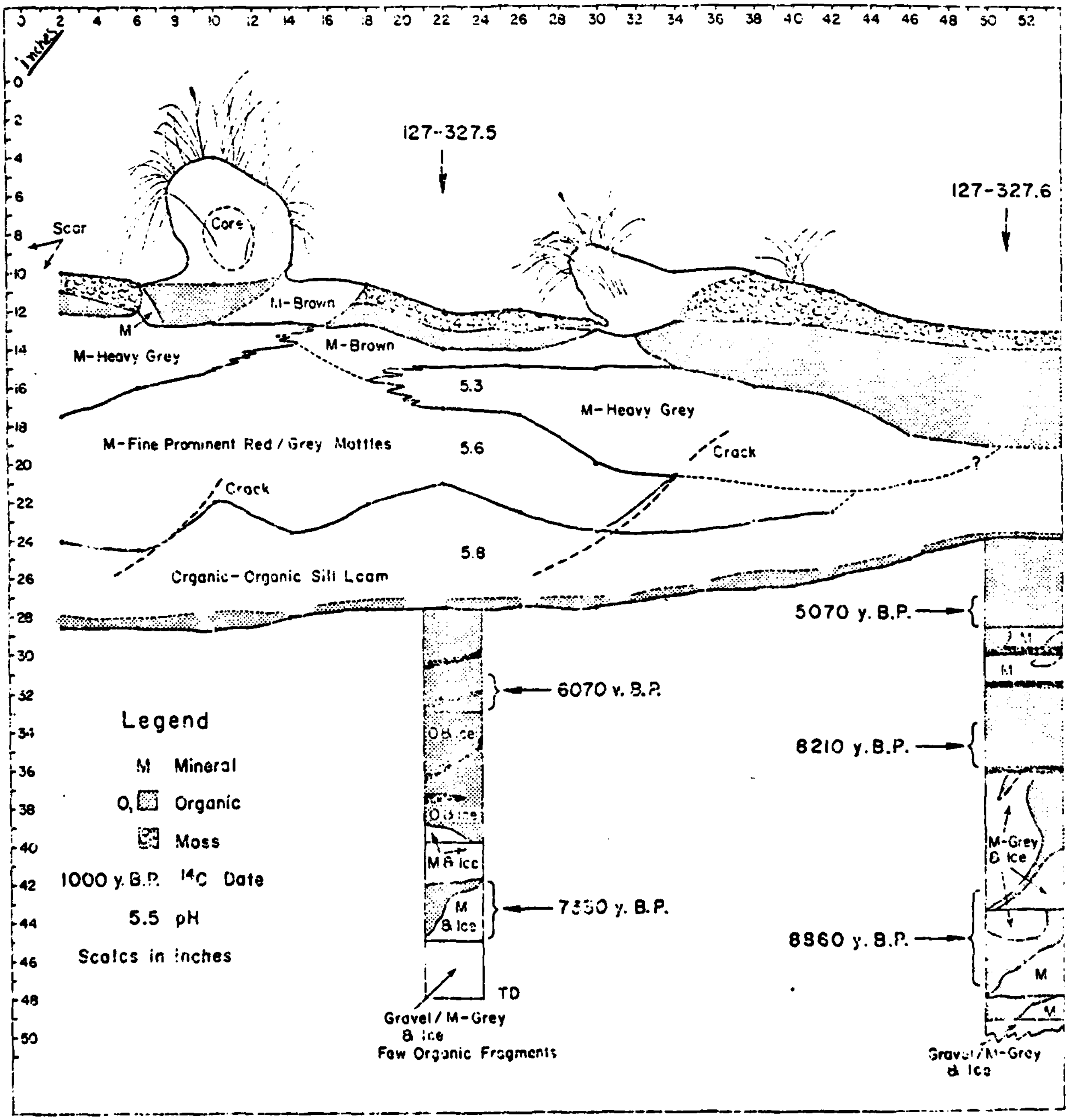


Fig.15. Cross-section of tussock, intertussock and frost scar association typical of landform 5 (Fig.12).

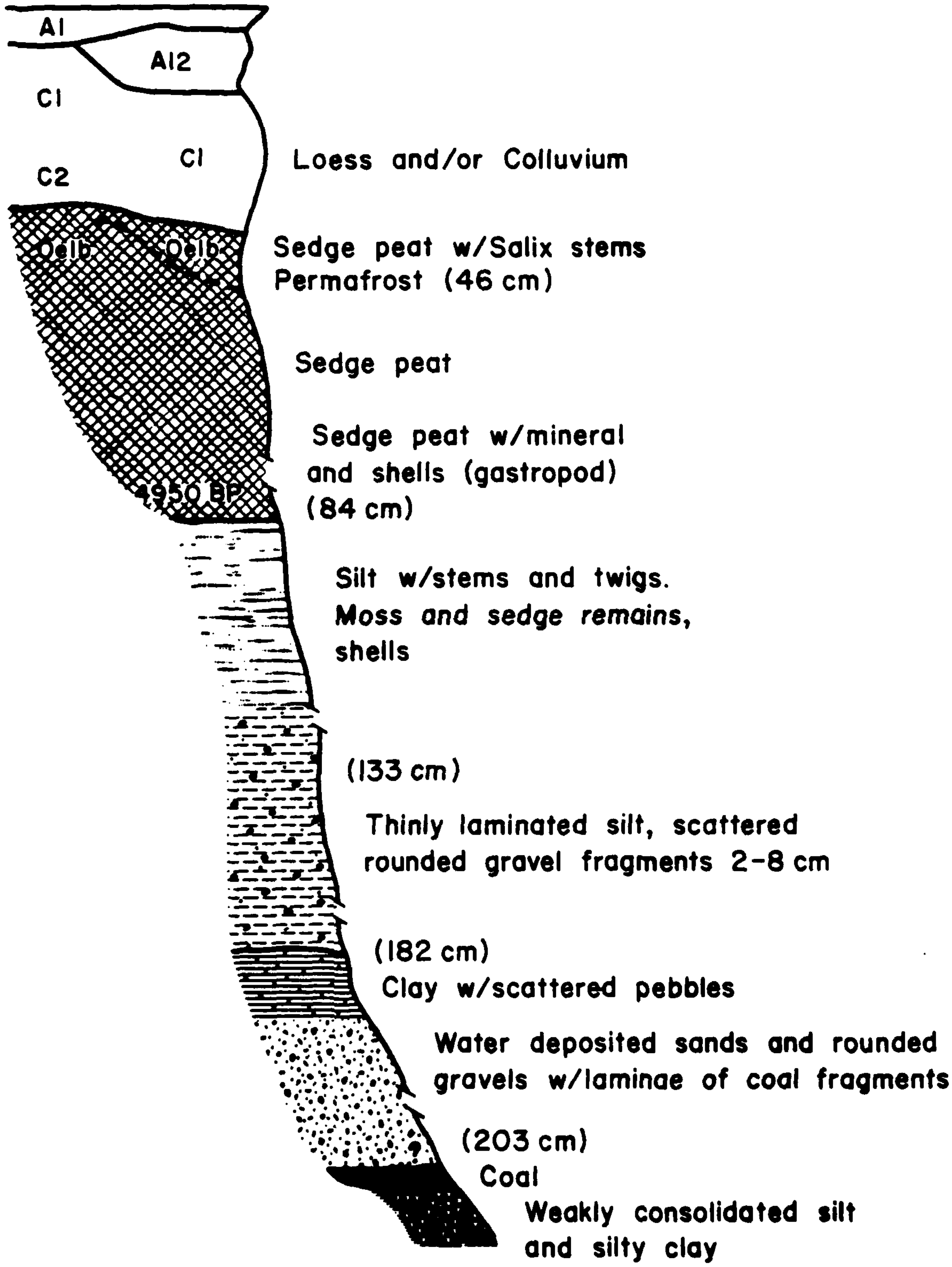


Fig.16 . Sketch of exposure in stream cut (see location 325.1 on Fig.12.) Vertical exaggeration increases from bottom up.

vegetation. It appears that a brief period of organic accumulation occurred after the mineral interruption and before headward erosion of the stream exposed the sediments and permitted thermokarst and thermal erosion to convert once poorly defined ice wedge polygons (developed in the meadow) to high centered polygons.

Evidence from other sites along the haul road suggests many of the marshy areas occurring in channel-like depressions or in closed basins may have undergone a similar series of events over the last 10,000 years i.e., filling with water washed or colluvial materials from the surrounding slopes followed by a shallow pond and/or marsh stage. There is also some evidence to suggest a relatively recent phase of thermal erosion. Thermokarst is occurring and bringing about the development of high centered polygons and possibly the reinstitution of active drainage.

Appendix A
Selected Edaphic Characteristics
List of Annotations

1	soil pH determined in field. 1:5 soil/water suspension
2	soil pH determined in laboratory. 1:1 soil/water paste
3	soil pH determined in laboratory. 1:1 soil/water paste using .01 m $CaCl_2$
4	field colors determined with Munsell color chips
5	Refer to Appendix B and figures
T	trace amount
DC	Citrate-dithionite extraction
VC	Very coarse sand 1-2 mm; C coarse sand 1-0.5 mm, M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	coarse silt .50-20 μm; F fine silt 20-2 μm.
C	coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam, loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam, silty clay loam.

Sagwon

Selected Edaphic Characteristics

Soil Profile[5]	Depth (cm)	Horizon	Color[4]	% Organic Carbon	Exchangeable Cations Meq/100 g Ca	Mg	K	H	Base Sat(%)	Fe(%) CD	Mn(%) CD	(Al(%)) CD	pH		Particle Size VC	C	sands mm(%) M	F	VF	TOT	silt/clay µm(%) C	F	C	F	Text Class
327.2	0-1	O1/A1	5YR2/2	13.6	13.7	1.7	0.54			0.6	0.038	0.078	5.1	4.8[2,3]	30	19	11	13	1	75	9	14	2	T	ls
	1-8	A1/2/E	5YR4/2	3.3	3.2	0.4	0.11			0.5	0.003	0.053	4.7	4.2	32	26	14	16	1	88	2	6	4	T	s
	8-19	B21	5YR5/4	1.0				6.7		0.9	0.002	0.078	4.8	4.0	34	25	11	12	2	82	3	9	3	3	ls
	19-28	B22	10YR5/6	T	0.3	0.1	0.03	4.6	8	0.7	0.002	0.083	4.7	4.0	33	27	10	11	2	83	2	11	2	2	ls
	28-48	B23	10YR5/4	T	0.2	0.1	0.03	3.9	8	1.2	0.001	0.058	4.7	4.0	33	19	12	22	3	89	2	5	4	1	s
	48-61	C1	2.5YR4/4	T	38.3	12.2	0.54	4.5	92	0.7	0.000	0.105	4.8	3.9	3	7	12	65	7	93	2	4	1	T	s
	61-86	C2	2.5YR4/2	T	18.1	6.7	0.28	5.6	82	0.7	0.000	0.155	4.7	4.0	2	3	4	58	13	81	5	10	3	1	ls
327.4	0-5	O11	10YR5/4	42.2	30.9	8.9	3.74			0.07	0.041	0.015	4.5	3.9											
	5-13	O12	5YR3/3	44.7	43.2	10.7	2.03	58.4	49	0.14	0.100	0.038	4.9	4.4											
	13-23	Oa1	5YR3/2	29.4	28.1	2.8	0.48	48.5	42	3.40	0.920	0.340	5.1	5.7											
	23-25	BCg	10YR4/2																						
327.5	0-4	O1	5YR3/2	27.4	17.1	3.4	1.28						5.1												
	4-14	B2g	5YR5/1	1.8	6.7	1.5	0.10			1.2	0.007	0.125	5.3	4.8	2	2	6	8	3	19	16	43	18	4	sil
	14-25	B22g	10YR4/2	2.8	10.0	2.1	0.11			1.6	0.015	0.163	5.5	5.1	T	2	6	8	3	18	16	40	16	11	sil
	25-34	B3	10YR4/2	12.7	19.0	3.0	0.19			1.6	0.013	0.267	4.5		T	1	4	5	2	13	21	35	19	12	sil
	34-41	A1b	10YR2/1	15.6	29.2	2.3	0.22			2.0	2.500	0.193	5.1												
327.3	0-5	O1	5YR3/2																						
	5-14	O2	5YR2/2																						
	14-18	BCg	10YR4/3	5.1	4.5	1.6	0.24			1.3	0.017	0.165	4.5	4.0	T	1	5	5	2	13	21	41	15	10	sil
	18-38	C1g	5YR4/1	2.3	5.4	1.1	0.07			1.5	0.010	0.128	5.1	4.3	T	1	5	5	2	14	18	44	14	11	sil
	38-46	C2g/A1b	10YR3/1	6.8	16.3	1.9	0.10			1.2	0.014	0.123	5.3	4.8	T	2	6	4	2	14	20	41	14	11	sil
	46-51	A12b	10YR2/1																						
	51+	C3g	10YR4/1																						

Appendix B

Selected profile descriptions of the soils of the Sagwon Uplands site. Refer to Figs. 11 and 12 and Appendix A for topographic setting and edaphic characteristics.

Site:	Happy Valley (Sagwon uplands) 127-327.2
Microrelief:	Snow bank slope below outcrop; weak stripes, some deflation patches. Slope 12%.
Vegetation:	*Arctostaphylos alpina*; *Betula exilis*; moss; lichen; scattered grasses; *Dryas octopetala*
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-1 01/A1	Dark reddish brown (5YR 2/2) organic loamy sand; loose; roots abundant. Abrupt, smooth boundary.
1-8 E	Dark reddish grey (5YR 4/2) fine gravelly coarse sand and finely divided organic matter; larger gravel fragments have iron coats on bottom; roots common. Abrupt, wavy boundary.
8-19 B21	Reddish brown (5YR 5/4) loamy sand; weak fine aggregates of sand with loam matrix; silt coats patchy on upper surface of rock fragments; iron coats patchy on lower surface; roots common. Abrupt, wavy boundary.
19-28 B22	Yellowish brown (10YR 5/6) loamy sand; loose; thick silt coats on upper side of rock fragments and binding finer sand grains; roots common. Abrupt, wavy boundary.
28-48 B23	Yellowish brown (10YR 5/4) medium to coarse sand and granules with sand grains cemented to them; loose; few roots. Abrupt, wavy boundary.

Happy Valley 127-327.2

Depth/Horizon (cm)	
48-61 C1	Olive brown (2.5YR 4/4) fine sand; loose; few rock fragments with thin patchy silt coats; roots absent. Abrupt, wavy boundary.
61-86 C2	< 20% gravel fragments with thin patchy silt coats; roots absent. Profile terminated 2 September 1976. Frozen at 50 cm.

Site:	Happy Valley (Sagwon uplands) 127-327.3
Microrelief:	Tussock element of tussock tundra. Slope 5%
Vegetation:	<u>Eriophorum vaginatum</u>
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
8-0	<u>Eriophorum vaginatum</u> tussock
0-5 01	Dark reddish brown (5YR 3/3) dense coarsely fibrous mat of <u>E</u>. <u>vaginatum</u> stems. Abrupt, wavy boundary.
5-14 02	Dark reddish brown (5YR 2/2) as above.
14-18 BCg	Brown (10YR 4/3) silt loam; coarse fibers and dead roots common; live roots common; no structure; fine, weak yellowish brown mottles. Abrupt, ruptic boundary.
18-38 C1g	Dark grey (5YR 4/1) silt loam; weak medium platy structure; strong, medium reddish yellow (7.5YR 6/8) and dark brown (7.5YR 4/4) mottles (~ 40% of horizon); roots common. Abrupt, wavy boundary.
38-46 C2g	Very dark grey (10YR 3/1) silt loam; weak fine platy structure; few organic fragments; few, weak, fine dark grey brown (2.5YR 4/2) mottles; roots common to few. Abrupt, wavy boundary. Frozen 3 September 76.
46-51 A1bf	Black (10YR 2/1) fibrous sedge peat; ^{14}C. 1730 y.B.P.
51+ C3f	Grey (10YR 4/1) silt loam.

Site:	Happy Valley (Sagwon uplands) 127-327.4
Microrelief:	Intertussock depression in tussock tundra. See 327.3. Slope 5%.
Vegetation:	_Sphagnum_ moss; _Hylocomium_ sp.; _Cassiope tetragona_; _Vaccinium vitis-idaea_
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Living vegetation
0-5 Oi	Yellowish brown (10YR 5/4) coarse fibrous _Sphagnum_ peat; loose. Abrupt, smooth to ruptic boundary.
5-13 Oi2	Dark reddish brown (5YR 3/3) medium fibrous _Sphagnum_ peat with numerous woody fragments; weak medium platy structure; live roots common. Abrupt, smooth, ruptic boundary.
13-23 Oa1	Dark reddish brown (5YR 3/2) sapric organic; stems to 1 cm common; horizon breaks down easily, live roots common. Abrupt, smooth, ruptic boundary.
23-25 BCg	Dark grey brown (10YR 4/2) fine sandy loam; weak, fine dark yellowish brown (10YR 4/6) and very dark grey brown (10YR 3/2) mottles. Frozen. 3 September 1976.

Site:	Happy Valley (Sagwon uplands) 127-327.5
Microrelief:	Tussock tundra. Slope 2%
Vegetation:	Acrocarpus mosses; lichens; _Vaccinium vitis-idaea_
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Living vegetation
0-4 01	Dark reddish brown (5YR 3/2) medium fibrous peat (moss and _E. vaginatum_); loose. Abrupt, smooth, ruptic boundary.
4-14 B2g	Grey (5YR 5/1) silt loam; medium fine platy structure; upper 3-4 cm has granular structure; many prominent yellowish red (5YR 5/8) and dark yellowish brown (10YR 4/6) mottles; few roots. Abrupt, smooth, ruptic boundary.
14-25 B22g	Dark grey brown (10YR 4/2) silt loam; friable; weak fine platy structure, breaks to strong fine angular blocky units (crumbly); many fine prominent dark yellowish brown (10YR 3/6) mottles; organic fragments common. Abrupt, smooth to wavy boundary.
25-34 B3	Dark grey brown (10YR 4/2) organic silt loam; weak fine platy structure; friable; roots common to few. Abrupt to clear, wavy boundary.
34-41 Alb	Black (10YR 2/1) sapric organic; enmixtures of above horizon; sporadic concentrations of fibrous _E. vaginatum_ fragments; roots few to common. Frozen. 3 September 1976.

Appendix C

Area (% of Total) summary for all soil-landform map units appearing in Fig.12.

Map Unit	Area (%)
1,10,4	.52
2,1,1	1.3
2,1P, 1	1.8
2,3,1	.57
2,4,1	.13
2,4,3	.24
3,4,2	.87
3,4,3	4.07
4,2,1	.41
4-5,4,1	1.57
21,8,2	.53
24,5,1	18.29
24,5,2	28.13
24,5,3	9.48
24,7,1	12.22
24,7,2	2.10
24,8,2	10.62
32,9,4	1.74
34,2,1	1.95
52,1,1	3.36

Toolik Site

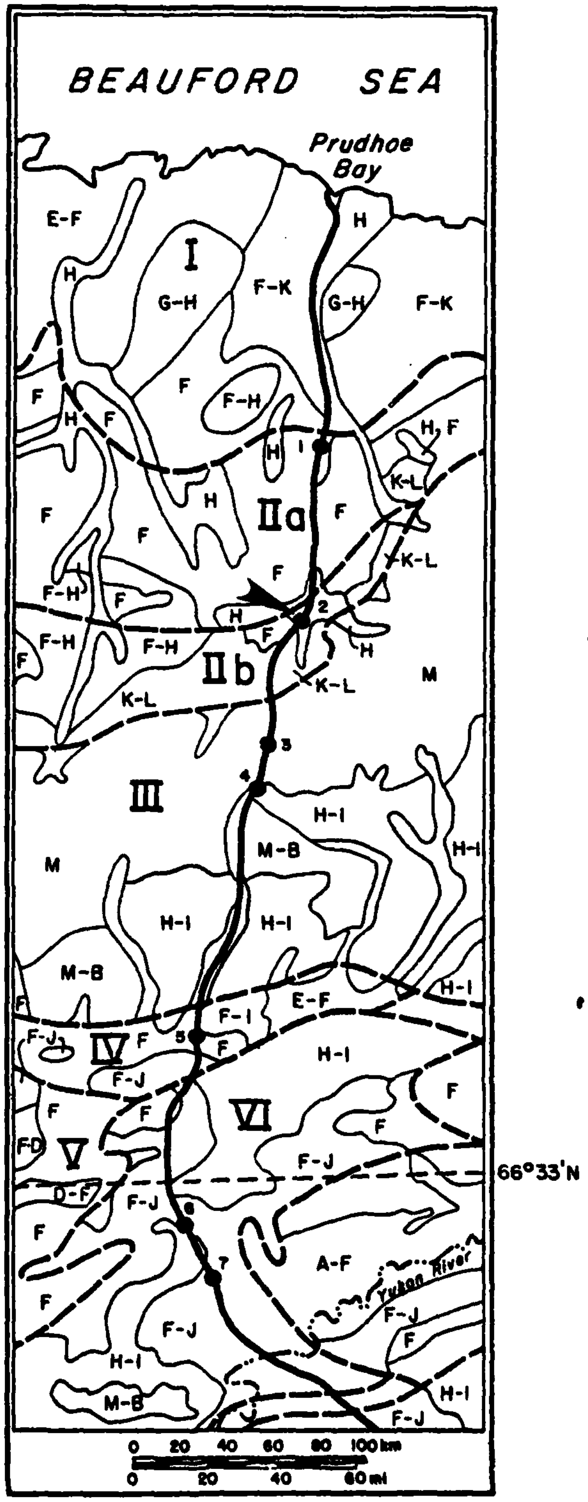


Fig. 17. Map showing position of Toolik site with respect to generalized physiographic and soils boundaries. Refer to Fig. 10 for legend.

Physical Geography

Geology

The Toolik site and the area approximately 17 km north and south of it is underlain by north dipping Lower Cretaceous rocks consisting of greywacke, sandstone, siltstone, shale and conglomerate. This sequence is in part equivalent to rocks of the Torok and Kuparuk formations that underlie the Archimedes Ridge and Knifeblade Ridge sites in the western Arctic Foothills. (USGS Preliminary Geologic Map of Alaska 1978 and Chapman and Sable, 1960). Although no outcrops occur within the map area, rock is exposed in a barrow pit not far from it and along parts of the Sagavanirktok River in the same region.

Unlike the Sagwon site, that at Toolik has been overridden by ice 3 and perhaps 4 times during the Pleistocene. Probably the most recent ice advance or readvance onto the site itself occurred approximately 13,000 years B.P. (Hamilton and Porter, 1975). During this phase of glaciation a grey loam to clay loam till was deposited on already rounded uplands along with numerous erratic boulders many of which can be seen especially on crest areas. What appeared to be an earlier, reddish till was exposed in an excavation south of the map site near the Kuparuk River. Considerable water was associated with retreat and downwasting of the ice as evidenced by extensive kames north of the study site and in the lowland areas immediately east of the map area. Stratified sands and gravels were also noted in one excavation on a crest position (mile post 117.2) below about 50 cm of bouldery till(?).

South of the map site and generally south of the Kuparuk River the amount of boulders (including what appear to be boulder moraines) increases greatly. Kame deposits are a common associate in this region. These deposits may be related to a younger readvance of the ice perhaps around 12,000 years B.P. (Hamilton and Porter, 1975). The readvance probably did not affect the Toolik map site. In any case the site was free of ice by a minimum of 10,375 ± 265 Y.B.P. (a peat date obtained from a basin 10 km south of the map area and possible by 15,000 Y.B.P., M. Bergman, personal communication). Human occupancy of the 13,000 Y.B.P. moraine complex some 5 km north of the map site occurred 10,540 ± Y.P.B. (Hamilton and Porter, 1975). Thus it might be assumed that within 2000 years of retreat of the ice the Toolik map area probably looked very much as it does today.

Topography

Maximum elevations within the map area, near the southern boundary of the Arctic Foothills (Wahrhaftig, 1965) are somewhat less than 950 m (about 680 meters more than the Sagwon uplands site). Relative relief differences are generally between 30 and 50 meters. While the topographic grain immediately south of the area is strongly developed along a lone NW-SE that of the map site is only weakly developed in that direction.

Broad interfluves, commonly with small perennial wet spots separate drainage basins. Some streams dischange into the Toolik River and eventually the Kuparuk River while others drain to the Sagavanirktok River. Slopes are long and convex. Many terminate abruptly on broad swampy stream basins. Commonly the head water areas of these basins are characterized by strangmoor and numerous pools, some connected

(beaded) some solitary, separated by or flanked by low peat plateaus (Palsas) or high centered polygons (Fig.18). Other slopes terminate in narrower boulder cloaked valleys often flanked by discontinuous kames.

Perhaps the most striking feature of the landscape is the pattern of ridges and swales radiating from the broad interfluve areas (Fig.19). Although careful observation reveals these features extend toward the crest well beyond midslope they become increasingly well defined from that point to the adjacent valleys. In fact, the ridges which near the base of the slope may be 50 cm above the adjacent swale or water track commonly breakup into discrete rectilinear elements that can be followed out into the broad drainage head. The spacing of the ridge and water track pairs is quite variable but near the base of slopes 8 m is probably representative. Strangmoor is commonly found within the water tracks. A mode of formation of these features will be considered later.

Erratic blocks, many a meter or more in diameter are common in the map area especially on the interfluves and lower parts of slopes where they may reach densities of 3/ha. Most are heavily encrusted with lichens and are half buried and partially engulfed by vegetation. Large diameter (2 m or more) block bordered polygons are common but of restricted extent on some interfluves (narrower ones). For the most part these features are difficult to see, most being partially covered with vegetation. All appear inactive or at least static although many have centers with active frost scars. Similar and more obvious block polygons are developed on the boulder covered interfluves south of the

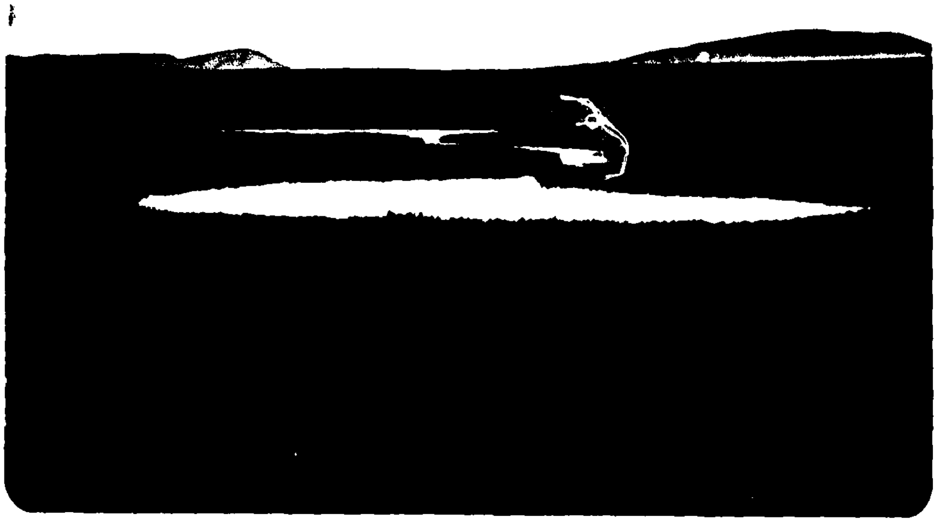


Fig. 18. Beaded drainage typical of the headwater area of many streams.

Fig. 19. Water tracks developed in tussock tundra north of the Toolik site. Vegetation contrast accentuates the tracks. U.S.G.S. Photo. COL-OV-54-64.

Kuparuk River. Here for the most part they are heavily lichen encrusted (and apparently stable). Many have well developed turfy soils in their centers. Boulder defended terraces and garlands are common on slopes, and many stream valleys head in felsenmeer covered basins.

Low centered ice wedge polygons are not common in the map area. High centered forms do occur in broad drainage heads.

Vegetation

The principal vegetation assemblage in the Toolik map area (like that at Sagwon) is upland tussock. It dominates the long convex slopes and consists of Eriophorum vaginatum (tussock) with variable amounts of Ledum palustre, Salix spp. and Betula exilis. Sphagnum spp. and other mosses dominate the center tussock areas.

Water tracks are characterized by large tussocks (generally free of encroachment by Cryptogams) and Salix sp.. Although the water tracks may not be apparent to the casual observer in summer, they are vividly outlined in late August when the Salix and Betula leaves turn yellow and red. The ridge elements also have tussocks, more subdued or at least more engulfed in Cryptogams, and lesser amounts of Salix and Betula.

Interfluve areas also are dominated by the tussock vegetation assemblage except in wet areas where Carex aquatilis becomes most common. C. aquatilis together with B. exilis Salix sp. and Sphagnum sp. dominate the marshy stream heads except where high centered polygons have developed. Here Vaccinium vitis idaea Dryas sp., Cassiope tetragona, mosses (not sphagnum); Thamnolia sp. and Vaccinium uliginosum occur with B. exilis and and L. palustre.

Well drained kame deposits although not included in the map area have *Dryas* sp., *Salix reticulata*, *Citraria richardsonii*, *Arctostaphalus* sp. together with an assortment of flowering annuals. The general area has been studied in detail by Webber *et al*. (1978).

Permafrost

As at Sagwon the Toolik map area is underlain by ice rich permafrost although the amount of ice may be somewhat less than at the Sagwon upland site. Ice wedge polygons that do occur on the uplands and slopes have little or no surface manifestation (possibly obscured by the tussock growth form). Low centered ice wedge polygons occur in the marshy valley areas and orthogonal forms may be developed on the lower parts of slopes adjacent to the drainages. This may account for the segmenting of the risers between water tracks as they approach the valley bottoms. There is no indication here that a slope normal element is accentuated higher on the slope (as it may be at Sagwon).

Bodies of massive (lenticular) ground ice undoubtedly exist beneath palsa-like forms in the broad marshy drainage areas (Fig. 18).

Thaw under tussock tundra tends to be rather uniform (Brown and Rickard, 1969). The 1977 late August active layer thickness on slopes at Toolik is 39 cm excluding frost scars which may thaw to 80 cm, this is slightly more than at Sagwon uplands site. In water track areas thaw is generally greater than on the slopes, averaging close to 50 cm. Shallowest thaw occurs in the palsas (< 35 cm) and in the better drained organic soils of high centered polygons.

Climate

The Toolik map site is wetter and somewhat warmer than the site at Sagwon Uplands (Haugen and Brown, 1980, Fig. 4). Wind data collected over a period of three summers in support of a study of road dust (Everett, 1980) show a strong southerly component through the summer indicating the site is well beyond the influence of the Arctic Front during the thaw period. Winter directions are probably from the northeast. The April snow pack is close to 40 cm. Between 55 and 60% of the total precipitation falls as rain (Haugen, 1980).

Soils

Soils of the Toolik site are represented by 3 soil orders, Entisols (those showing little or no pedogenic development), Inceptisols (those with weak horizon development) and Histosols (organic soils). By far the most extensive soils (> 90%) are the Cryaquepts, the cold, wet Inceptisols, (Fig. 20) associated with the tussock tundra. Like their counterparts at Sagwon, Pergelic Cryaquepts with surface organic horizons < 20 cm thick form a complex at Toolik with Histic Pergelic Cryaquepts (commonly beneath tussocks or in intertussock areas where thick mats of moss are developed > 20 cm) and Pergelic Cryaquepts that commonly lack an organic (A/O) horizon or have only a very thin one (frost scar soils) (see Fig. 21). Soils of active frost scars properly belong with the Entisols however, at present there is no established taxa for them in that order. Such soils probably comprise 5 to 10% of most tussock tundra. The proportion

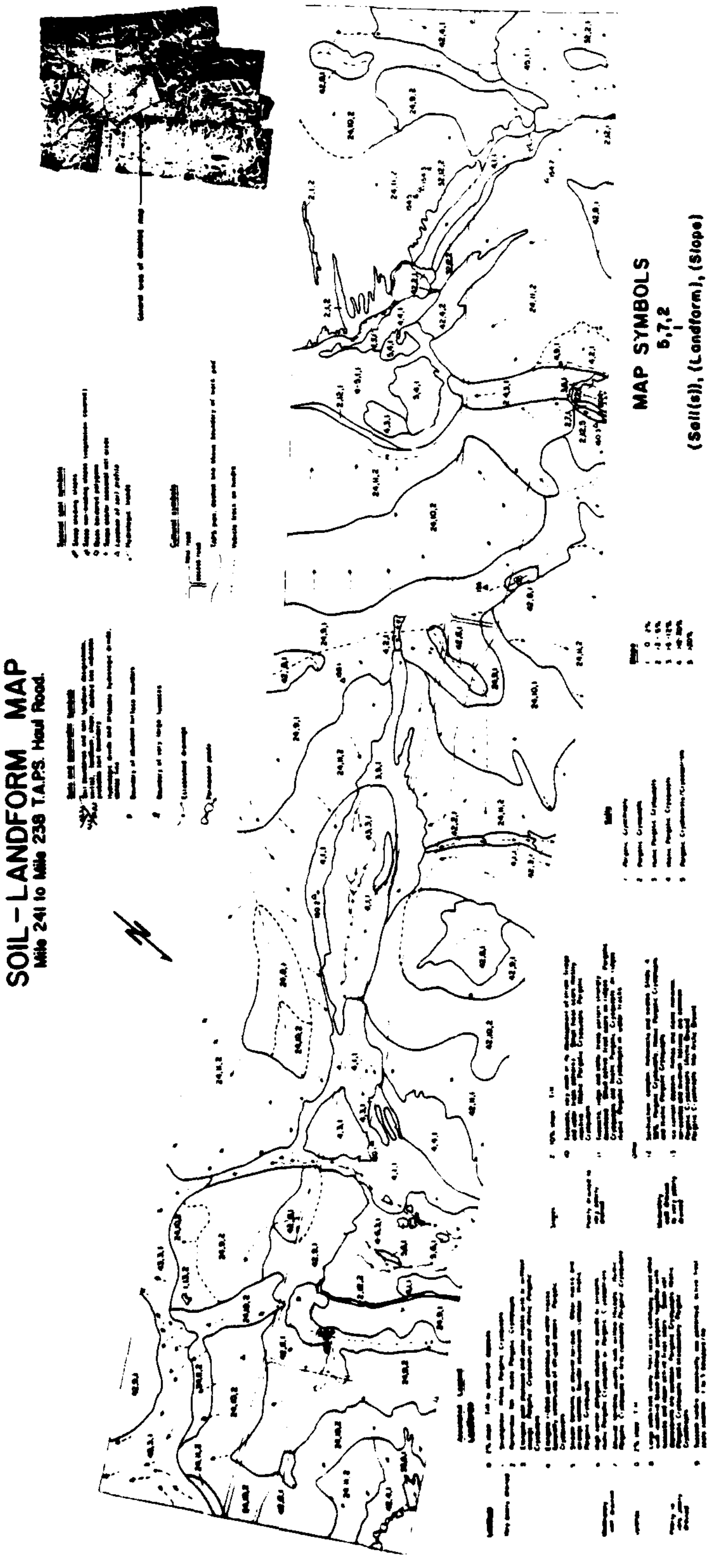

SOIL-LANDFORM MAP
Mile 241 to Mile 238 T.A.P.S. Haul Road.
MAP SYMBOLS
5,7,2
1
(Soil(s)), (Landform), (Slope)

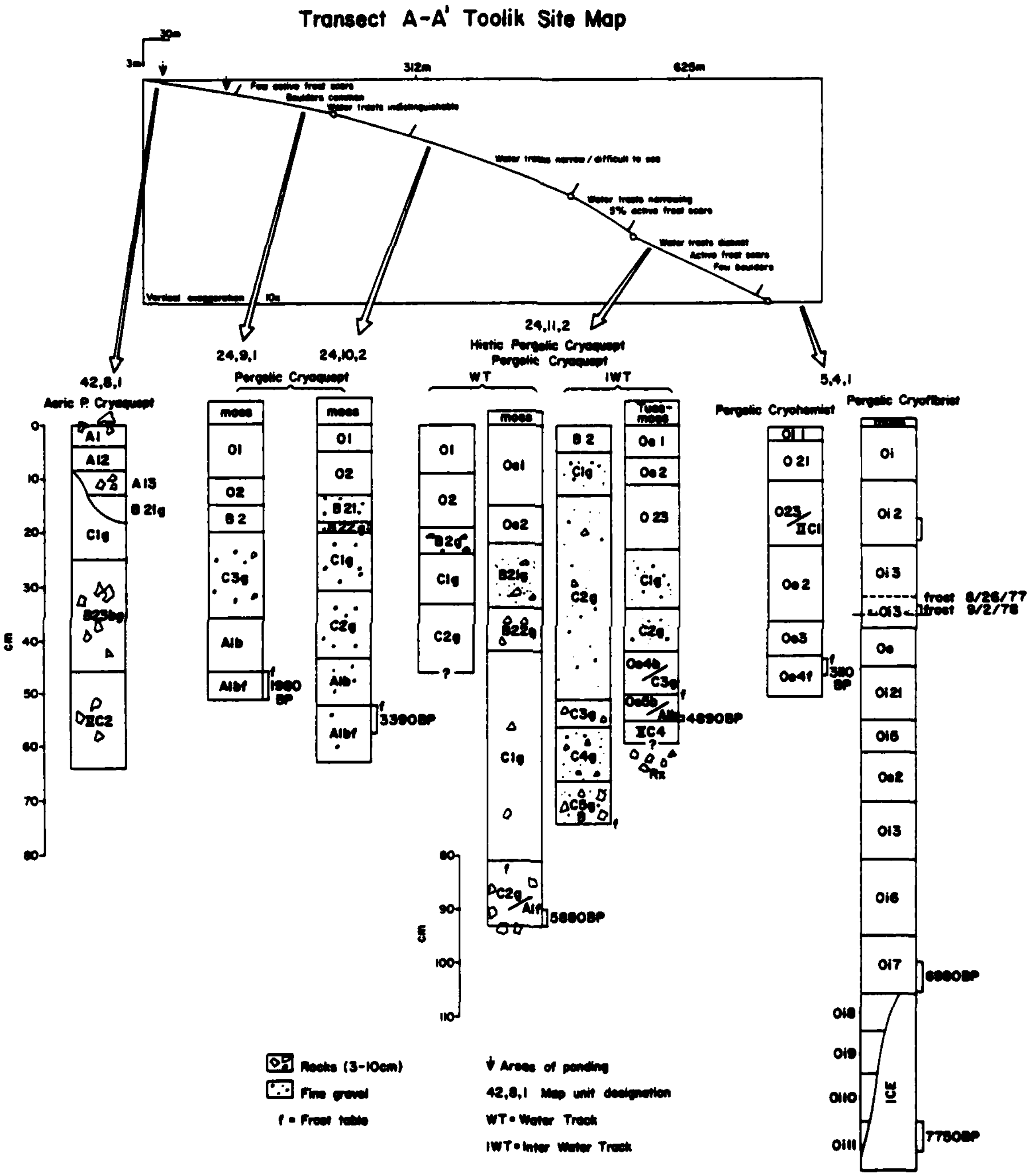
Fig. 20

of Histic Pergelic Cryaquepts increases on the lower 1/3 of most slopes especially in areas where water tracks are well developed and areas of strangmoor.

In the lowlands, especially stream head waters, thick organic soils, Pergelic Cryofibrists and Pergelic Cryohemists, occur in peat plateaus (palsas). Histosols (organic soils) whose upper horizons are composed of highly decomposed organic materials occur in high centered polygons where better drainage has permitted biological oxidation of the near surface peat. Below these Oa horizons the organic material is less well decomposed (Fig.21).

Upland areas because of their breadth are commonly wet or little different in terms of their soils than the slopes. Histic Pergelic Cryaquepts are generally somewhat more common than Pergelic Cryaquepts. In a few widely scattered areas occupying the centers of static block bordered polygons are Aeric Pergelic Cryaquepts. These soils are in most respects similar to the surrounding tussock tundra Cryaquepts except that their brighter colors (aeric) are indicative of better drainage attending deeper thaw. These soils also have a higher proportion of cobble size fragments (Fig.21).

Soils developed in the relatively well drained kame deposits outside the map area are classified as Pergelic Cryochrepts. Some of these soils particularly those of snowbank areas where Empetrum sp. and Cassiope tetragona are common have a thin well developed alluvial horizon (A2) that indicates removal of iron and aluminum by organic acids. These soils have counterparts at the Sagwon upland site. They become more



Transect A-A' Toolik Site Map
312m
625m
Vertical exaggeration 10x
42,8,1
Aeric P. Cryaquept
24,9,1
24,10,2
Pergelic Cryaquept
24,11,2
Histic Pergelic Cryaquept
Pergelic Cryaquept
WT
IWT
5,4,1
Pergelic Cryohemist
Pergelic Cryofibrist
cm
frost 8/26/77
frost 9/2/78
1980 BP
3390BP
4890BP
380 BP
5880BP
6880BP
7750BP
ICE
Rocks (3-10cm)
Fine gravel
f = Frost table
Areas of ponding
42,8,1 Map unit designation
WT = Water Track
IWT = Inter Water Track

Fig. 21

important and better developed in the Atigun Canyon area and south of the continental divide where they develop on well drained sites under white spruce (Picea glauca).

Landscape Evolution

Repeated advances of Pleistocene ice from the Brooks Range have sculptured the topography producing rounded till mantled hills and moraines and have probably accentuated certain structural trends. Withdrawl of the last ice to reach this area took place between 13,000 and 12,000 years B.P. (Hamilton and Porter, 1975). Erosion of the vegetation-free till-solifluction mainly in the form of stripes- together with surface runoff probably produced a radial pattern of shallow troughs and slightly elevated, elongate frost scars. Fine grained particulate material was removed to adjacent, shallow basins, many of which may have been closed. The establishment of vegetation probably came about rapidly, certainly less than 1500 years and probably within a few hundred years (Ugolini, 1966). In the lowland areas moss and sedge peat began to develop at least 10,000 years B.P. and has continued, apparently uninterrupted except for the development of massive segregation ice in certain areas. Ice wedge polygons developed in some poorly drained areas (crests and lowlands). These forms probably also developed to some extent on slopes. Crest areas probably developed discontinuous areas of boulders (a lag-like surface) which were quickly organized into block bordered polygons.

It is not unreasonable to assume a tussock tundra similar to the modern one quickly established on the slopes. Burial of surface organic

horizons by expansion of frost scars either on the surface or by injection of mineral material into organic horizons has occurred for at least the last 6000 years (at Sagwon site these processes have been documented to nearly 9000 years B.P.). It is quite likely frost scar activity waxes and waines aperiodically if not cyclically in response to a complex series of vegetation, soil nutrient availability and climate interactions, some understanding of which is now emerging (Chapin et al., 1978; Miller, unpublished, 1976).

The radiate pattern of water tracks and ridges acts to channel surface flow principally during meltoff. Moisture released as the active layer thaws probably also moves slowly within the water tracks as evidenced by the convex downslope strangs (strangmoor) developed in many of them.

The beaded drainage (Fig. 18) developed in some stream channels together with the high centered polygons is indicative of active thermokarst and lowering of the local base level. This phenomena is noted almost universally north of the Brooks Range. It is not determined whether this is a transitory response to some local factors and thus a "normal" character of high ice permafrost or if it signals a regional climatic change.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	soil pH determined in field. 1:5 soil/water suspension
2	soil pH determined in laboratory. 1:1 soil/water paste
3	soil pH determined in laboratory. 1:1 soil/water paste using .01 m $CaCl_2$
4	field colors determined with Munsell color chips
5	Refer to Appendix B and figures
T	trace amount
DC	Citrate-dithionite extraction
VC	Very coarse sand 1-2 mm; C coarse sand 1-0.5 mm, M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	coarse silt .50-20 μm; F fine silt 20-2 μm.
C	coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam, loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam, silty clay loam.

Toolik
Selected Edaphic Characteristics

Soil[5] Profile	Depth (cm)	Horizon	Color[4]	% Organic carbon	Exchangeable Cations Meq/100 g Ca	Mg	K	H	Base Sat(%)	Fe(%) CD	Mn(%) CD	Al(%) CD	pH	Particle Size sands mm(%) VC	C	M	F	VF	TOT	silt/clay μm(%) C	F	C	F'	Text Class
													2,3											
158.1	2-9	B21	10YR4/6	2.2	0.3	0.1	0.09			1.8	0.009	0.17	4.7 3.9	4	6	6	12	8	36	9	25	22	8	l
	9-42	BCg	10YR4/3	1.7	0.3	0.1	0.08			1.8	0.008	0.14	4.9 3.9	5	6	6	12	7	36	12	27	20	6	l
	42-52	Cl	10YR4/1	2.4	0.7	0.1	0.19			1.0	0.015	0.09	4.5 3.9	4	7	6	14	9	39	11	26	19	6	l
	52-62	C2g	10YR3/2	7.8	1.3	0.3	0.28			2.0	0.025	0.19	4.5 3.9	3	5	5	10	6	29	10	22	30	9	cl
													2,3											
158.2	0-10	Oil	5YR4/4	41.7	10.5	5.9	2.40	45.8	29	0.3	0.035	0.13	4.6 3.3											
	10-15	Oal	5YR3/4	23.0	3.2	1.5	0.37	51.5	9	2.9	0.143	0.06	4.6 3.6											
	15-20	Al	5YR3/3	17.5	0.7	0.3	0.09	45.7	2	4.1	0.151	0.75	5.3 3.8											
	20-36	BC	10YR5/2	1.4	0.3	0.2	0.04	8.6	5	1.0	T	0.11	4.9 3.9	4	7	7	14	9	41	18	22	17	2	l
	36-46	Alb	10YR2/2	18.5	1.8	0.5	0.31						4.9 4.0											
	46-51	Oab	10YR2/1																					
													2,3											
154.3	0-9	Oil	5YR3/2																					
	9-19	Oel	5YR3/2	23.7	3.9	2.5	0.44	51.7	12	2.2	0.010	0.03	4.3 3.7											
	19-24	B2g	10YR4/2	4.5	0.4	0.3	0.05	19.2	4				4.5 3.8	3	5	5	12	8	33	9	27	21	10	cl
	24-33	Clg	5Y5/1	3.2	0.3	0.2	0.03	14.1	3	1.3	T	0.15	4.5 3.8	3	6	6	13	9	36	8	26	22	9	cl
	33-46	C2g	5Y5/1	3.2	0.3	0.3	0.04	17.3	3	1.7	0.001	0.17	4.7 3.9	4	6	6	13	8	36	8	26	20	10	cl
154.4	0-15	Oel	5YR2/1	35.6	14.0	5.3	0.26	89.8	18	5.0	0.024	0.28	4.3 3.6											
	15-22	Oe2	5YR3/3	30.0	12.3	4.6	0.25	49.1	26	2.0	0.010	0.36	4.3 3.7											
	22-34	B21g	-	2.3	0.4	0.5	0.03			0.4	T	0.09	4.6 3.9	3	6	7	14	10	40	12	26	17	5	l
	34-42	B22g	10YR4/3	4.1	0.7	0.7	0.04			1.9	0.002	0.18	4.7 3.9	3	6	6	12	8	35	10	24	23	8	cl
154.5	0-5	B21g	10YR4/3	3.0	0.3	0.3	0.10	12.1	5	1.5	0.001	0.14	4.4 3.8	4	6	7	14	9	40	7	28	18	8	l
	5-13	Clg	10YR5/2	2.3	0.4	0.7	0.04	11.8	9	1.1	0.001	0.11	4.7 3.9	3	5	7	15	10	39	10	27	17	7	l
	13-51	C2g	5Y5/1	2.0	0.3	0.3	0.04	11.3	5	0.7	0.001	0.10	4.6 3.8	2	5	6	15	10	39	11	28	16	7	l
	51-56	C3g	10YR4/2	3.0	0.4	0.3	0.05	15.1	5	1.1	T	0.12	4.6 3.8	2	5	6	14	9	37	10	28	17	8	l
	56-66	C4g	10YR3/2	5.6	0.7	0.2	0.05	20.3	5	1.4	0.002	0.17	4.3 3.8	4	6	6	13	8	36	10	26	20	9	cl
	66-74	C5g	10YR3/2	6.4	0.8	0.3	0.07	13.8	8	1.5	0.004	0.14	4.3 3.9	5	6	6	13	9	38	10	26	20	6	l
154.6	0-6	Oel	5YR3/2	38.1	13.9	7.9	2.05	75.8	24	2.1	0.036	0.25	4.3 3.8											
	6-11	Oe2	5YR3/3	37.0	6.6	4.4	0.70	105.0	10	3.4	0.014	0.29	4.3 3.6											
	11-23	Oe3	7.5YR4/4	36.1	4.2	2.4	0.43	47.4	13	0.9	0.004	0.58	4.4 3.7											
	23-34	Clg	10YR5/2	4.4	0.4	0.4	0.03	15.5	5	0.3	T	0.16	4.7 3.9	3	7	7	14	9	40	10	28	16	6	l
	34-42	C2g	10YR4/2	12.3	0.8	0.6	0.05	35.4	4	5.1	0.001	0.28	4.6 3.8	4	6	5	10	6	31	11	25	23	5	cl
	42-50	Oalb	10YR2/2	17.8	1.2	0.6	0.07	26.5	5	1.7	0.004	0.35	4.4 3.9											
160.3	0-4	Al	5YR2/2	22.8	12.7	3.4	0.90	40.4	30	1.5	0.150	0.29	4.6 4.1											
	4-8	A12	7.5YR3/2	12.2	4.1	0.9	0.21	27.5	16	1.3	0.003	0.23	4.6 4.2	7	11	8	13	7	46	17	23	11	3	l
	8-13	A13	10YR3/3	4.8	6.2	1.3	0.13	17.0	31	2.2	0.006	0.29	5.5 4.8	6	7	5	11	7	37	12	23	21	7	cl
	13-40	B	10YR4/4	3.3	7.7	1.1	0.09	17.0	34	1.9	0.004	0.21	6.1 5.3	6	8	6	12	9	42	10	24	16	8	l

Appendix B

Selected profile descriptions of the soils of the Toolik area. Refer to Figs. 20 and 21 and Appendix A for topographic setting and edaphic characteristics.

Site:	Toolik 117-158.1
Microrelief:	Frost scar. Diameter ~ 1 m. Few rocks on surface.
Vegetation:	Lichens and widely scattered Eriophorum vaginatum tussocks.
Classification:	Aeric Pergelic Cryaquept
Depth/Horizon (cm)	
3-9 B2	Dark yellow brown (10YR 4/6) loam; dry; friable; strong, fine granular structure; few roots. Abrupt, wavy boundary.
9-42 BCg	Brown (10YR 4/3) mixed color; clay loam; moist; massive; strong fine prominent grey brown (10YR 5/2) and moderate fine dark grey brown (10YR 4/2) mottles; weak coarse platy structure; few roots; mottles decrease with depth and become coarse; fine rock fragments common. Clear, wavy boundary.
42-52 C1	Dark grey (10YR 4/1) clay loam; moist; massive; 10-15% coarse and fine rock fragments increasing with depth. Clear, wavy boundary.
52-62 C2g	Very dark grey brown (10YR 3/2) clay loam, 20% granules and small gravel fragments; few medium very dark grey (10YR 3/1) mottles. Frozen. 28 August 76.

Site:	Toolik 117-158.2
Microrelief:	Tussock complex adjacent to frost scar (117-158.1)
Vegetation:	Moss; Betula exilis; Ledum palustre; Cassiope tetragona; Eriophorum vaginatum; Dactalyna arctica.
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	Living vegetation
0-10 01	Reddish brown to pink (5YR 4/4) to (5YR 7/4) squeezed Sphagnum moss; fibrous; breaks down with slight difficulty; roots common. Abrupt, smooth to wavy boundary.
10-15 02	Dark reddish brown-reddish brown (5YR 3/4) to (5YR 4/3) squeezed sapric organic; few sedge fibers; some fine sand; weak fine platy structure; roots common. Abrupt, wavy boundary.
15-20 A1	Dark reddish brown (5YR 3/3) organic loam; friable; weak fine granular structure; possibly some humilluvic materials. Abrupt, wavy boundary.
20-36 BC	Reddish grey (10YR 5/2); fine sandy loam-loam; massive; granules and small rock fragments ~ 10%; weak coarse platy structure; few strong prominent yellowish brown (10YR 5/6) mottles; roots common; organic fragments common. Abrupt, wavy boundary.
36-46 IIC/Alb	Very dark brown (10YR 2/2) organic loam; organic fragments ~ 20%. Frozen 28 August 1976.
46-51 Oalf	Black (10YR 2/1) sapric organic. ^{14}C date = 1980 Y.B.P.

Site:	Toolik 117-154.3
Microrelief:	Hummocky water track - standing water between hummocks, slope < 1^{o}.
Vegetation:	_Eriophorum vaginatum_ hummocks. _Ledum palustre_; _Betula exilis_ some _Carex_ sp. Interhummock with _Hylocomium_ sp.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-9 01	Dark reddish brown (5YR 3/2) coarse fibrous peat; compressed; mostly _E. vaginatum_ roots and stems; mineral content increases with depth. Abrupt, ruptic boundary.
9-19 02	Dark reddish brown (5YR 3/3) medium fibrous organic; _E. vaginatum_ roots and moss remains; breaks down with moderate difficulty; mineral content variable. Abrupt, smooth boundary.
19-24 B2g	Dark grey brown (10YR 4/2) clay loam; many medium prominent yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4) mottles. Abrupt, smooth boundary.
24-33 C1g	Grey (5YR 5/1) clay loam; as above; 2-5 cm rock fragments ~ 20% by volume; roots common. Clear, smooth boundary.
33-46 C2g	Grey (5YR 5/1) clay loam; wet; moderate, medium platy structure to structureless; coarse prominent strong brown (10YR 5/8) and brown (10YR 5/3) mottles; medium prominent grey brown (10YR 5/2) mottles; roots common. Boundary not observed due to flooding.

Site	Toolik 117-154.4
Microrelief:	Interhummock depression
Vegetation:	Hylocomium sp. and Sphagnum sp.
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Living moss and Ledum roots
0-15 Oe1	Black (5YR 2/1) hemic moss peat; some dead Eriophorum vaginatum roots; live roots abundant. Abrupt, smooth, ruptic boundary.
15-22 Oe2	Dark reddish brown (5YR 3/3) loamy hemic/sapric Sphagnum peat; few sedge fibers; structureless to weak fine platy structure. Abrupt, smooth, ruptic boundary.
22-34 B21g	Brown (10YR 4/3) clay loam; structureless to weak fine platy structure; medium prominent dark yellowish brown (10YR 4/4-4/6) mottles; few coarse dark brown (7.5YR 4/4) mottles near boundary; roots common, ~ 10% coarse rock fragments. Abrupt, smooth boundary.
34-36 B22g	Brown (10YR 4/3) clay loam; medium prominent grey (5YR 4/1) mottles and fine prominent grey (10YR 5/1) mottles; few roots; boundary not observed due to flooding; frozen at 81 cm, 6 September 1976. Core drilled to 93 cm. Sapric organic. ^{14}C date 5880 Y.B.P.

Site:	Toolik 117-154.5
Microrelief:	Frost scar - several small isolated tussocks on surface.
Vegetation:	Sporadic algal crust with scattered Eriophorum vaginatum tussocks
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-5 B2	Dark brown (10YR 4/3) loam; structureless when wet; weak fine granular structure dry; ~ 5% fine rock fragments; common prominent yellowish brown (10YR 5/6) mottles; roots common. Abrupt, smooth boundary.
5-13 C1g	Grey brown (10YR 5/2) gritty loam; moderate fine platy structure; many prominent coarse dark yellowish brown (10YR 4/6) and brown (10YR 4/3) mottles; few roots. Abrupt, smooth boundary.
13-51 C2g	Grey (5Y 5/1) gritty loam; strong fine platy structure; many fine strong brown (7.5YR 5/8) and prominent coarse brown (10YR 5/6) mottles; rock fragments < 2%; few roots. Abrupt, smooth boundary.
51-56 C3g	Dark grey brown (10YR 4/2) loam; moderate medium platy structure; 5-10% rock fragments; weak to moderate coarse dark yellowish brown (10YR 3/4) mottles; roots absent. Abrupt, smooth boundary.
56-66 C4g	Very dark grey brown (10YR 3/2) gritty clay loam; weak medium platy structure; fine rock fragments 10-15%; few moderate medium dark yellowish brown (10YR 3/4) mottles. Clear, smooth boundary.

Depth/Hoirzon (cm)	
66-74 C5g	Very dark grey brown (10YR 3/2) gritty loam; weak fine platy structure; fine and medium rock fragments 20-25% increasing in size and number at frost table (74 cm, 7 September 1976).

Site: Toolik 117-154.6

Microrelief: Intertussock area (partly tussock)

Vegetation: *Sphagnum* sp. and *Betula exilis*

Classification: Humic Histic Pergelic Cryaquept (Pergelic Cryaquept)

Depth/Horizon (cm)	
4-0	Living moss
0-6 Oe1	Dark reddish brown (5YR 3/2) hemic peat, mostly *Sphagnum* with some sedge fibers; loose; coarse and fine roots abundant. Abrupt, smooth boundary.
6-11 Oe2	Dark reddish brown (5YR 3/3) hemic *Sphagnum* peat; moderately decomposed with some sedge sheaths and roots; few woody fragments; fine and medium roots plentiful. Abrupt, smooth boundary.
11-23 Oe3	Dark brown (7.5YR 4/4) hemic/sapric sedge peat with some moss; highly decomposed; few woody fragments; strong to moderate fine platy structure; horizon darkens near boundary. Abrupt, smooth boundary.
23-34 C1g	Greyish brown (10YR 5/2) gritty loam to loamy fine sand. Moderate fine platy structure; few weak dark yellowish brown (10YR 4/4) mottles; few roots. Abrupt, ruptic boundary.
34-42 C2g	Dark greyish brown (10YR 4/2) gritty clay loam; moderate weak platy structure; few dark yellowish brown (10YR 3/6) weak fine mottles near boundary; few inclusions of black (10YR 2/1) organic matter. Clear to abrupt, smooth boundary.

Depth/Horizon (cm)	
42-50 Oa1/IIC3g	Very dark brown (10YR 2/2) sapric organic; highly decomposed; moderate fine platy structure; few inclusions of dark grey brown (10YR 4/2) mineral with sporadic prominent grey brown (10YR 4/1) mottles near upper boundary. Frozen, 7 September 1976.
50-55 Oe3f	Very dark brown (10YR 2/2) hemic organic; many fine ice lenses. Abrupt, smooth boundary.
55-59 IIIC4f	Dark grey (10YR 5/1) loam; many fine ice lenses; many rock fragments. Hole terminated because of rocks.

Appendix C

Area (% of Total) summary for all soil-landform map units appearing in Fig. 3.

Map Unit	Area (%)	Map Unit	Area (%)
1,13,2	.01	4,1,1	4.47
2,1,2	.44	4,2,1	.36
2,2,1	.15	4,3,1	1.12
2,7,1	.05	4,4,1	1.48
2,12,1	.15	4,9,1	.22
2,12,2	.10	4-6,3,1	2.22
2,12,5	.39	42,2,1	.16
24,3,1	.79	42,3,1	.08
24,8,1	1.12	42,4,1	2.19
24,9,1	7.43	42,4,2	.56
24,9,2	6.57	42,8,1	3.74
24,10,1	2.75	42,9,1	3.16
24,10,2	13.50	42,10,2	3.68
24,11,2	29.30	42,11,1	1.69
3,5,1	1.22	43,3,1	5.12
3,6,1	.05	45,1,1	2.30
32,2,1	.15	4-5,1,1	1.91
32,12,2	.55	5,4,1	.68
36,6,1	.08	5,6,1	.08

Archimedes Ridge Site

Physical Geography

Geology

The study area is within the northern section of the Arctic Foothills physiographic province (Wahrhaftig, 1965) immediately north of Archimedes Ridge (Fig. 1). Within the map area the north flowing Utukok River breaches the east-west trending Archimedes Ridge Anticline the axis of which bisects the map area (Chapman and Sable, 1960). The ridge itself consittutes the southern limb of the anticline and is composed of coarse textured, interbedded silty shales, siltstones and sandstones of the lower Cretaceous Kukpowruk formation. The soft core rocks, through which the Utukok River has cut a broad valley, are composed of clay shales, claystones and silty shales of the lower Cretaceous Torok formation (Chapman and Sable, 1960). Even though the area is well north of the glacial limit the river is bounded by discontinuous gravel terraces that presumably represent Quaternary outwash deposits (Williams *et al*., 1977).

Topography and surface characteristics

The Archimedes Ridge site typifies a sizeable area corresponding roughly to the southern half of the northern section of the Arctic Foothills, especially from Cape Beaufort to the Chandler River. This area is characterized by spectacular east-west trending valleys and ridges of folded Cretaceous rocks. General crest elevations along Archimedes Ridge are between 530 m and 590 m with maximum concordant elevations of 630 m. The north limb of the Anticline is somewhat lower, ranging between 375 and 470 m. The upper elevations of both limbs are steep with differential erosional etching producing contoured bedrock terraces separated by colluvial slopes. At elevations below the base of the Kukpowruk formation

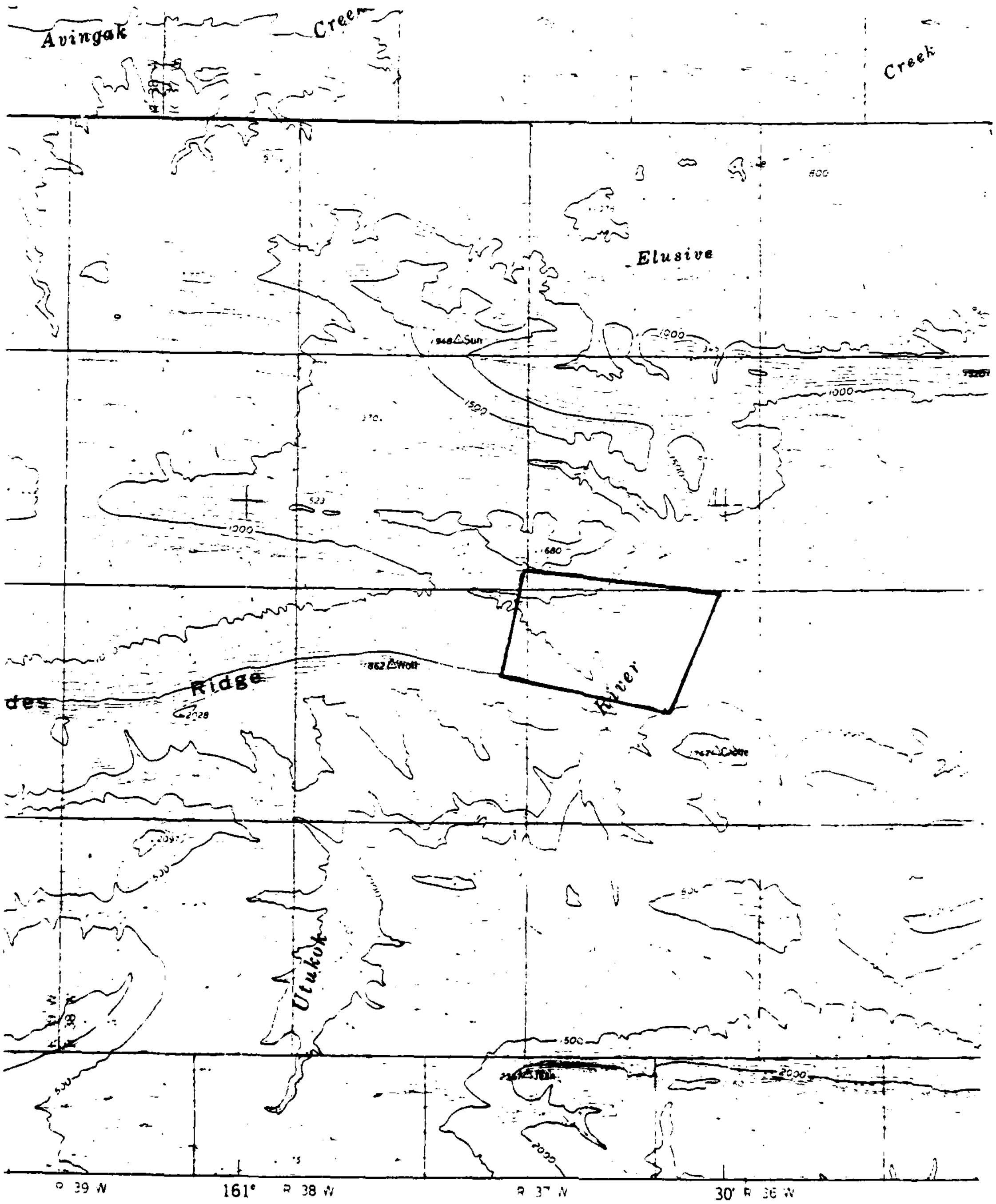


Fig.22. Location of the Archimedes Ridge soil-landform map area. U.S. Geological Survey (1974) 1:250,000 series.

erosion has produced long uniform (27%) slopes on the soft shale of the Torok formation. These slopes are characterized by pediments and pediment spurs and remnants (Fig.23 and 24) that are separated by shallow parallel second and third order drainages. The broader downslope regions of the drainages have well developed peat islands and strangmoor. As the channels narrow up-slope the microrelief becomes chaotic with many solifluction and thermokarst features and forms characteristic of rapid mass movement, especially mudflows. Interfluves (pediment surfaces) and interfluve remnants are characterized by tussock-frost scar tundra. The frost scars constitute between 10 and 30% of such surfaces. Large diameter, raised center, contour oriented, orthogonal polygons are common also. The relief contrast of these features is slight and in most areas they are lost from view in a sea of tussocks. Similar conditions occur on slopes in the Knifeblade Ridge, Sagwon and Toolik map areas.

Above the pediments, steep strike slopes below outcrops of the Kukpowruk formation are underlain by colluvium and slabby talus. Mass movement, especially solifluction characterizes the surface of these slopes. In many cases the interstital spaces of the talus are open (at least above the permafrost) and act as channels for meltwater which occasionally erupts to the surface (Fig.25).

The map site is bisected by the north-flowing Utukok River, which after leaving its narrow valley through Archimedes Ridge, flows across the soft shale core of the anticline as a braided stream. A broad marshy lowland extends up to 2.8 km east of the river. This area is underlain by gravels (probably Quaternary, Chapman and Sable, 1960) and contains vestages of

Fig. 23. Aerial view of pediment surface on rocks of the Torok formation decending from Archimedes Ridge (Kukpowruk formation) toward the center of the anticline. Area adjoins the soil landform map site on the west. BAR photo 44-85.

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SOIL-LANDSCAPE RELATIONS AT SELECTED SITES ALONG ENVIRONMENTAL --ETC(U)
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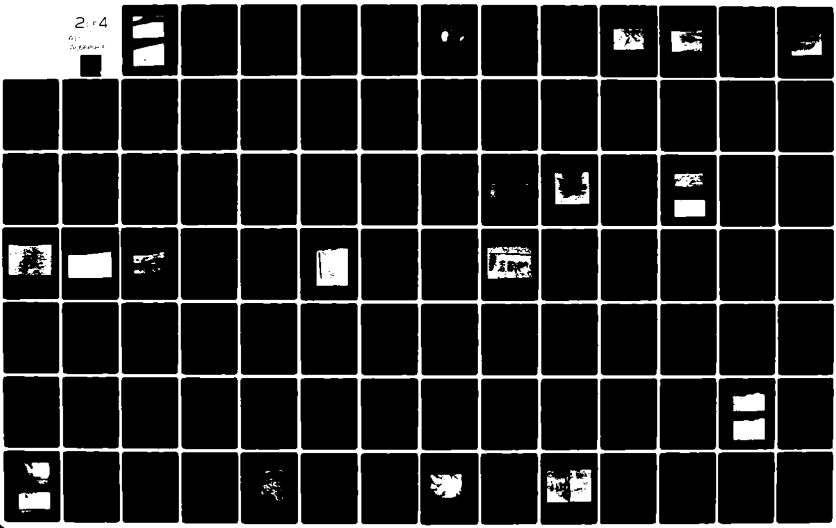
UNCLASSIFIED ARO-14037.1-GS NL

2 of 4



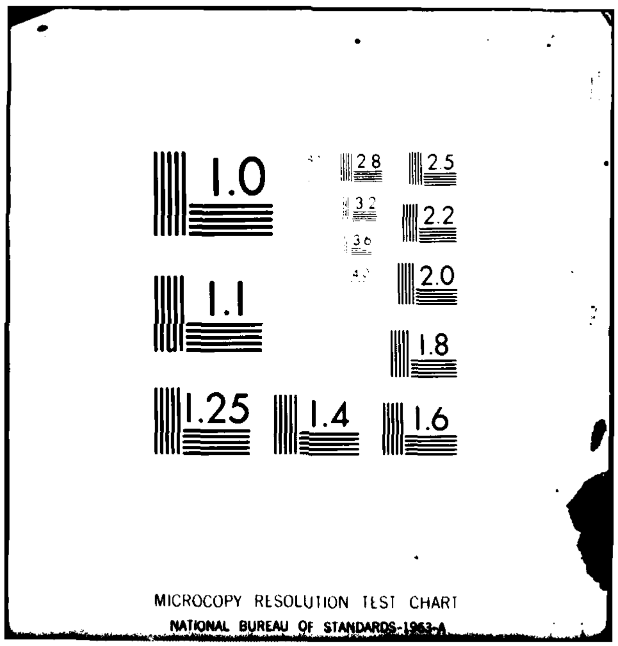

1.0
2.8
2.5
3.2
2.2
3.6
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Fig. 24. Pediment surface on shale of the Torok formation north of Archimedes Ridge. Slope with tussock-frost scar tundra occupies foreground.

Fig.25. Explosive piping on a colluvial (talus) slope composed of fragments of Kukpowruk formation.

former river channels in the form of low discontinuous terraces, point bars and channels and interpoint bar areas. The interpoint bar areas are characterized by low centered polygons, peat islands and strangmoor. Individual strangs are 3 to 4 m wide and 10 to 30 m long. The longest terrace related to the modern river is about 2.5 m above the present stream and is well expressed on the east side of the river (Fig. 26, unit 2,9,1). A lower terrace (1.5 m) is represented sporadically on both sides of the river (Fig. 26, unit 5,8,1). This terrace supports dense stands of *Salix alaxensis* that in some areas is between 40 and 60 years old. The terrace may be inundated briefly during infrequent periods of exceptionally high water.

Remnants of at least two older terraces composed of gravel and cobbles are found at elevations considerably above the lower, recent Utukok River terraces. The highest terrace crops out at two sites along a divide west of the river (Fig. 26). Downslope remnants of a second terrace crop out at 28 m. The presence of the terrace gravels may have acted to preserve this interfluve (pediment) from distruction by thermokarst. Knickpoints in many of the larger drainages are common at about the elevation of the second terrace. Remnants of possibly a third and lower terrace from the prominent bluffs (6 m ±) along the west side of the river. However, the gravels associated with the feature may have been derived from higher terraces by erosion. On the east side of the valley only one terrace was identified with certainty. This terrace probably corresponds to the second or intermediate level terrace of the west side of the river. Terrace remnants at similar elevations were identified by Chapman and Sable (1960) both north and south of the present map area. Although the

origin of the terraces is not well understood they are probably Quaternary in age and represent outwash (Chapman and Sable, 1960; Williams _et al._, 1977). A mammoth tusk was found by Chapman and Sable in gravels of the lowest terrace north of the Archimedes Ridge site.

Active and inactive stripes are found in the map area and are most common on the pediments just back from terminal areas that end above steep cut banks. Very large (18 to 20 m wide) inactive stripes are developed on a narrow pediment remnant cut in shale below sandstone outcrops in the northeast corner of the map area (see Fig. 6 and soil profiles 81.7 and 81.8, Appendix A). Nonsorted circles and weakly defined stone polygons are common to gravel terraces and some sandstone outcrops (profile 81.9).

Permafrost

The Archimedes Ridge site lies within the zone of continuous permafrost. Thaw depths measured between 15 and 20 August ranged from 27 cm in the _Sphagnum_-_Salix_ peat islands to > 75 cm in the well drained gravel terraces with sparse vegetation where ice bonded permafrost probably occurs at depths greater than 1 meter. In the centers of wet low-centered polygons and the flarks of strangmoor thaw depths between 55 and 60 cm are common. Thaw on the long tussock slopes averages 34 cm, nearly the same as the Sagwon site and slightly less than at Toolik.

Masses of lenticular ice are found beneath the peat islands. Ice wedge ice is probably not extensive except beneath the poorly drained lowlands associated with the Quaternary terraces to the east of the Utukok River. Beneath the troughs of the very weakly expressed polygons on the tussock tundra slopes, the extent of wedge ice is probably determined by the thickness of the unconsolidated colluvium.

Vegetation

Within the map area vegetation on pediment slopes is that which typifies foothill province tussocks: _Ledum palustre_, _Salix_ sp., _Betula_ sp., _Vaccinium vitis-idaea_ and _Rubus chamoemorus_. Unlike the Toolik and Sagwon tussock tundra _Lupinus_ sp. is common on all other slopes that display a substantial degree of instability (see also sections on West Oumalik and Knifeblade Ridge).

Eriophorum augustifolium and/or _Carex aquatilis_ dominate the vegetation of the very wet areas (the centers of low centered polygons, flarks of strangmoor, the shallow drains of the pediment slopes and meander cutoffs. _Salix_ sp., _Betula_ sp., _Vaccinium uliginorum_ and _Sphagnum_ sp. become important on the more elevated polygon rims and strangs. _Betula_ sp. and _Sphagnum_ sp. dominate the peat islands as they do in nearly all instances where these features occur.

Well and moderately well-drained gravel terrace sites have interrupted covers of _Dryas_ sp., _Salix phlebophylla_ with variable amounts of _Betula_ sp., mosses and lichens, _Vaccinium uliginosum_, _Empetrum_ sp. and _Arctostaphylus_ sp. in depressed areas. _Lupinus_ sp. is common to some of the recent terraces. Dense thickets of _Salix alaxensis_ or mixtures of _S. alaxensis_ and various other species of willow occupy the less frequently inundated portions of goosenecks.

Soils

Within the Archimedes Ridge map area nearly 50% of the soils begong to the Histic subgroup of Cryaquepts (Inceptisols). At the level of accuracy possible in a survey such as the one reported here it is not possible to

further differentiate, morphologically, the Histic subgroup on conventional taxonomic criteria. However, recognizable and mappable differences do exist within this subgroup most commonly within the Histic epipedon itself i.e., the state of organic decomposition. In the field it is useful to use a variation of the suborder terminology for Histosols in combination with the term Histic e.g, fibrohistic to define a Histic Pergelic Cryaquept in which the epipedon is composed of little decomposed (fibrous) organic material. Other combinations include Hemihistic and Saprohistic. A nomenclature was suggested by Parkinson (1978) for Histic Pergelic Cryaquept soils in the Prudhoe Bay area.

Histosols (those soils with > 40 cm of organic materials) may be found on nearly all landforms except the well-drained ones. Their occurrence is goverened by some very local physical and/or biological circumstance e.g., over thickening of the organic horizon due to solifluction, and thus they do not comprise mappable units at the scale employed in Figure 26.

A soil complex consisting of a pedon composed of Histic Pergelic Cryaquepts and Pergelic Cryaquepts (those Cryaquepts lacking the necessary 25 cm of organic materials to define the Histic epipedon) and a frost scar soil dominates the tussock frost scar tundra of the continuous pediments and pediment remnants (Figs.26 and 27). The frost scar soil (presently classified as a Pergelic Cryaquept) properly belongs within the Entisol order as a Pergelic Cryaquent. Soil profiles 81.3 and 81.4 (Fig.27) typify the areas not occupied by frost scars. The pedon that they represent is typical also of the entire foothill region occupied by tussock tundra (see Sagwon, Toolik and Knifeblade Ridge site descriptions). The Histic epipedon or O horizons of these soils (Pedon) are commonly composed of humic organic material

SOIL LANDFORM MAP

ARCHIMEDES RIDGE - UTUKOK RIVER AREA

AUGUST, 1978

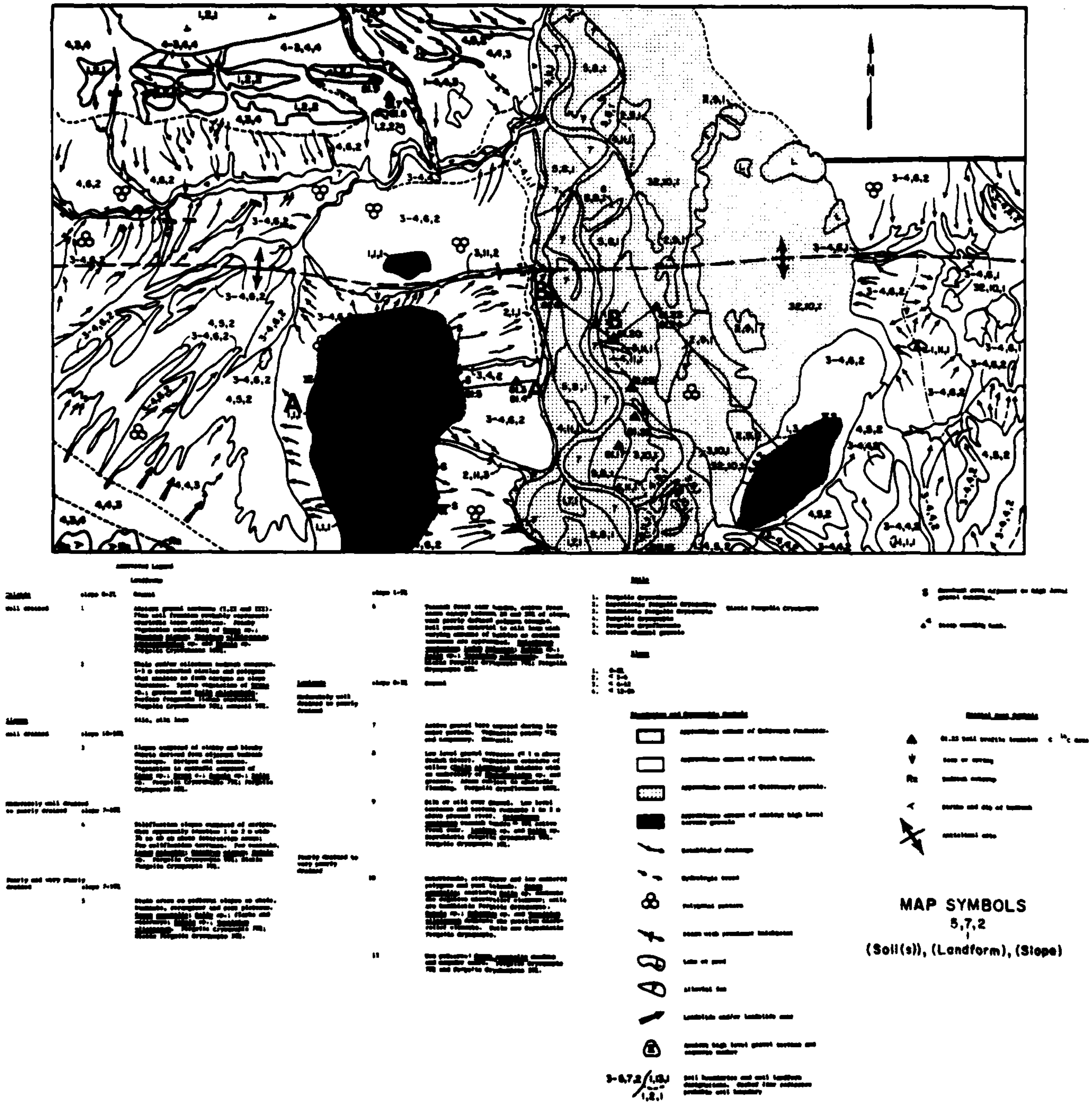


Fig. 26 Errata. Soil [illegible] on map designated 7 to read 6.
Note. Soils designated [illegible] on well drained sites in heavily shaded areas are mostly Cryochrepts.

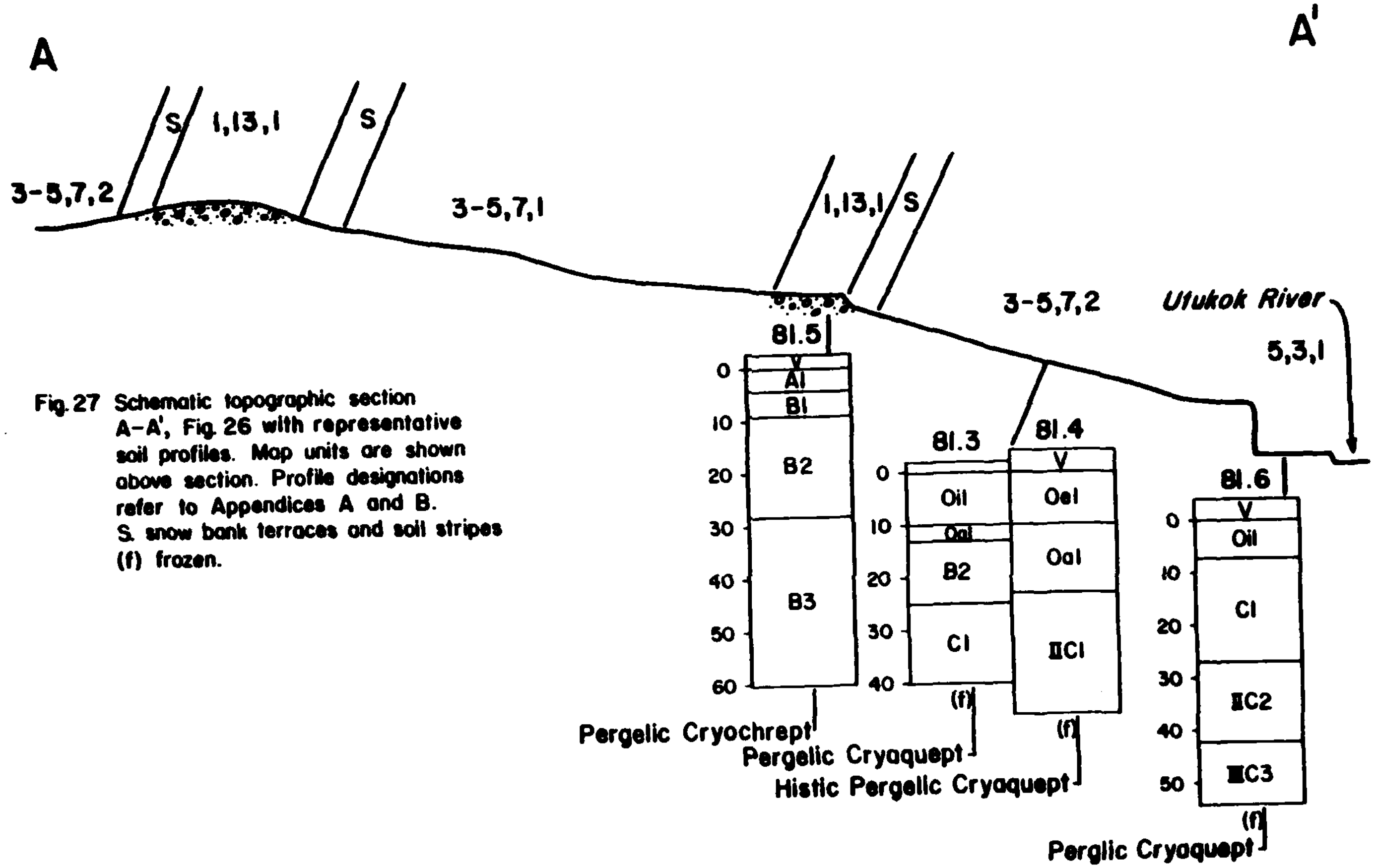


Fig. 27 Schematic topographic section A–A', Fig. 26 with representative soil profiles. Map units are shown above section. Profile designations refer to Appendices A and B.
S. snow bank terraces and soil stripes
(f) frozen.

overlying more highly decomposed (sapric) materials. Where Sphagnum or other mosses dominate, fibrous materials constitute the upper horizon, and the texturial state that constitutes 50% or more of the Histic epipedon determines the soil taxon. Dary grey, commonly mottled, silt loam textured mineral soil occurs below the organic horizons. The boundary is usually abrupt although enmixtures of sapric materials within the mineral (C) horizon are common. The C horizon is less acid than the organic horizons above. In areas close to sandstone or siltstone outcrops or gravel terrace remnants, rock fragments may comprise a small percent (by volume) of the C horizon. Permafrost is generally encountered between 40 and 50 cm however, within frost scars it may be at 60 to 70 cm.

On steeper parts of tussock frost scar slopes and on the south-facing pediment slopes seen in Figure 24,continuous and discontinuous stripes are common. The degree to which the stripe surface is active i.e., generally lacks vegetation ranges from 20-30% active in the tussock tundra to essentially inactive for those in Figure 28.

In the wet lowlands east of the Utukok River (Figs. 8 and 9) Hemihistic and Saprohistic and Saprohistic Pergelic Cryaquepts predominate. In the very wet areas (soil landform unit 32,10,1) are low centered and polygons, strangmoor and peat plateaus. The topographically raised elements of these landforms, polygon rims, strangs and the peat plateau are sites of Saprohistic Pergelic Cryaquepts or Hemihistic Pergelic Cryaquepts (profile 81.23). Lower elements, polygon centers, flarks and wet patternless areas are characterized by Fibrohistic or more commonly Hemihistic Pergelic Cryaquepts, profile 81.24. The peat plateaus are similar in most respects to those encountered in other areas of the foothills and south of the Brooks Range e.g., The Tramway Bar site.

Below the organic horizons of the soils silt loam textured mineral materials of variable thickness overly fluvial gravels. Active layer

Fig.28. Stripe pattern characteristic of pediment slopes north of the principal east flowing stream (Figs.24 and 26). Stripes composed of silt loam mineral soil are light areas defined by grass, Ledum palustre and Empetrum sp. and comprise 30-50% of the surface. Soil surface of interstripe areas is 30-40 cm below that of the stripe. Vegetation is characterized by Betula sp. and moss. The soil association consists of Hemihistic Pergelic Cryaquepts in the interstripe area (profile 81.8) and Pergelic Cryaquepts (Pergelic Cryaquepts) beneath the stripes (profile 81.7).

Fig. 29. Poorly drained and lowland area east of the Utukok River immediately north of Archimedes Ridge. Such areas are characterized by strangmoor (extreme right center), low centered polygons center of photograph and peat islands (dark areas in upper center of photograph). Long, smooth tussock tundra slopes appear west of the river and the discontinuous outcrops of terrace II can be seen near the crest of the pediment. Stripe slopes of the Kukpowruk formation can be seen at the extreme upper right of the photograph.

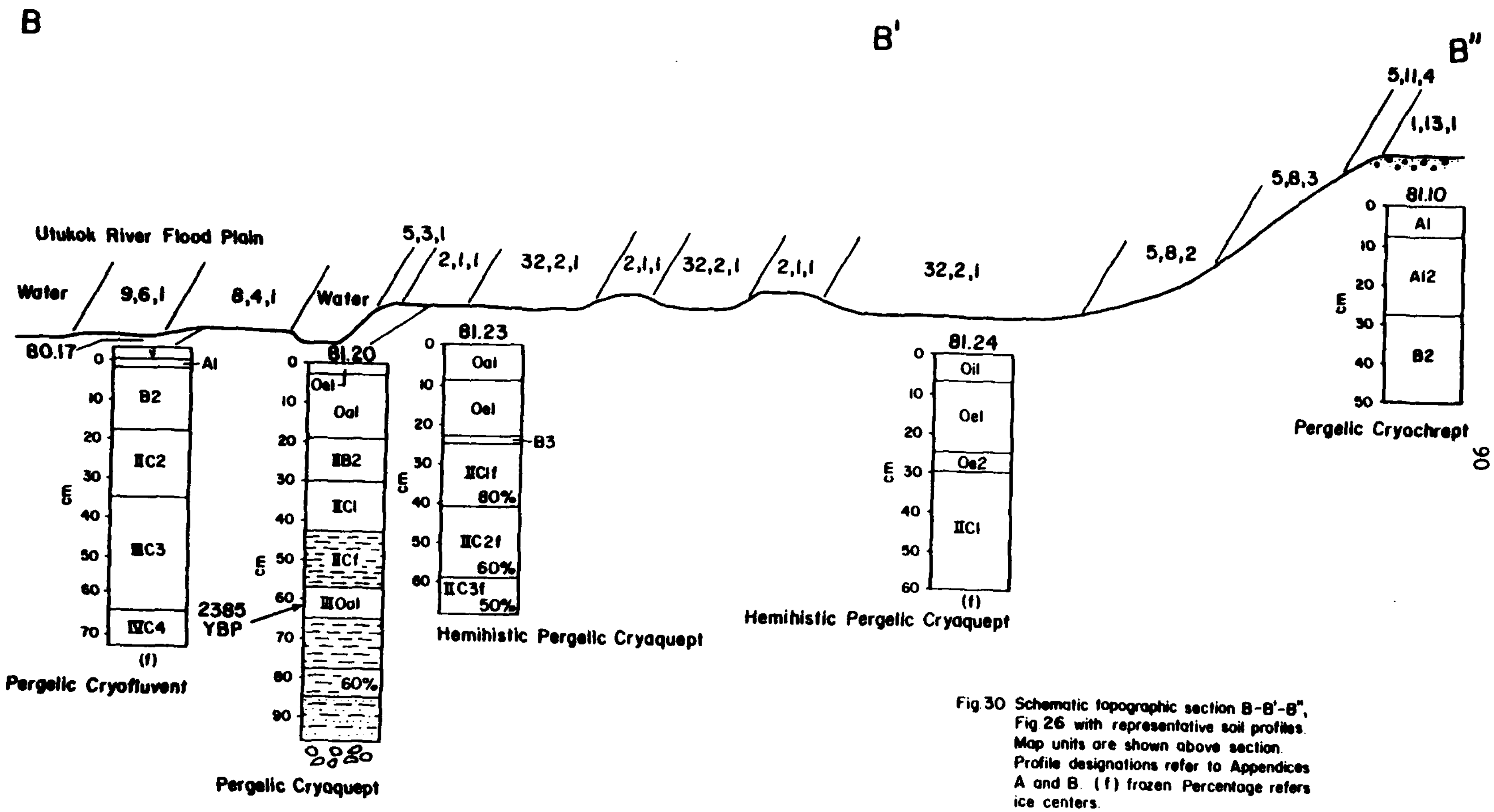


Fig.30 Schematic topographic section B-B'-B", Fig 26 with representative soil profiles. Map units are shown above section. Profile designations refer to Appendices A and B. (f) frozen. Percentage refers ice centers.

Fig. 31. A Pergelic Cryochrept soil typical of those developed on the ancient high level gravel terraces that occur sporadically along the Utukok River. The upper horizons are developed in silt loam textured materials that overlie the gravels. Counterparts of this soil are widely distributed throughout the arctic and have been found in the Peninsula area of west Antarctica.

thickness ranges widely, from 60 cm in the centers of polygons to 25 cm in the Betula covered peat plateaus.

Soil reaction (pH) of the organic horizons range from a slightly acid to near neutral. In the underlying frozen silt loam it is neutral to mildly alkaline.

Soils considered as well-drained occupy only a small part of the map area. There is a considerable range in their morphological and chemical profiles (see profile 81.1 and 81.9) and in their taxonomic position. Strongest profile development is found in soils of the gravel terrace remnants (Fig. 26) especially the higher two levels. The organic rich A1 horizon of this and similar soils (Figs. 27 and 31, profile 81.5) is medium acid while the underlying more mineral rich horizons are mildly to moderately alkaline. As is typical of many such Cryochrept soils throughout the arctic and subarctic carbonate precipitates are found on the underside of the larger gravel fragments while silt coats their upper surfaces. Iron precipitation within the B horizon does occur but is much less than in well-drained soils in gravels south of the Brooks Range. Similar profiles are developed in greywacky at Cape Thompson.

Profile 81.9, representing well-drained sites underlain by rocks of the Kukpowruk formation differs significantly, from the Cryorthents just described. Visual horizon differentiation is not possible and only a succession of C horizons can be defined, mostly on changes in the volume percentage of coarse fragments and extent of silt coats. The upper horizons are slightly less alkaline than those below and this probably represents leaching. The thick silt coats together with their vesicular character

and flow structures, which as depth increases, act as a matrix around the coarse fragments attest to significant water movement through the soil. Low, but rather constant organic carbon values (profile 81.9, Appendix B) add further support to this down profile water movement. Perhaps the largest percentage of the silt and clay size materials were derived by weathering of the local bedrock although some surely has been added by air infall.

Landscape Evolution

One of the most striking aspects of the map site and the very significant area of the fold belt of the western part of the foothills in general are the long smooth pediment slopes formed in shales exposed in the cores of anticlines. Whatever the range of processes were that produced the pediments it is certain that mudflow, at least in the region of the pediment angle was, and is, one of the most important. Creep is certainly important lower on the slopes. Both processes of course take place in the absence of permafrost but it is likely that the speed with which they occur is increased within a shallow saturated active layer. The thickness of the creeping mantle under tussock tundra is probably less than 2 m in most areas. Therefore it is questionable if the polygon outlines so common to these slopes convey the presence of significant volumes of wedge ice. However, cracking and ice may extend well into the weak shales.

The shallow, parallel and subparralled "solifluction channels" that cut the pediment slopes suggest a regrading of the surface. The channels,

many of which merge downslope, may represent thermokarst enlargement of slope normal ice wedge traces. The channels are the sites of active layer creep defined by strangmoor, or numerous peat islands supported by the accumulation of lenticular ice bodies. The drains appear to be extending headward rapidly, aided by mudflow (Figs. 23 and 26).

The original pediment surfaces certainly reflect a long period of construction dating probably well before the advent of the Quaternary, but after the major tectonic events of the Tertiary. High level early Quaternary or possibly even pre-Quaternary gravels (Chapman and Sable, 1960) found on the pediment surface immediately west of the Utukok River in the map area (Fig.26) may have served to protect the surface from the extensive regrading taking place on the adjacent pediment surfaces.

Landforms associated with the broad embayment east of the Utukok River and 2 or more meters above it are probably all of late Pleistocene and/or Holocene age and overlie or are constructed from reworked Quaternary gravels. Basal organic materials over gravel beneath a peat island which is topographically below the first prominent low level terrace (Fig.26) were found to be 2970 ± 120 Y.B.P. (DIC1320) (profile 81.23). A second date in the same area, but somewhat above the gravels was 2380 ± 155 (DIC1319), (profile 81.24). Loss of the drill prevented more detailed sampling of presumably older features farther inland.

The lowest terrace of the three recognized in the embayment area is little more than 2 m above the present channel of the Utukok. The soil is a Saprohistic Pergelic Cryaquept and the vegetation is composed of tussocks, moss and scattered Lupine. Other low level terrace remnants,

apparently no longer subject to flooding, occur on both sides of the river, some have alluvial fans built onto them while others have remnants of oxbows. These surfaces have Histic Pergelic Cryaquept soils. Still lower deposits, 1 m or less above the stream occur on both sides of the channel. Many of these support dense thickets of willow and are probably only infrequently flooded. Thin silt loam covers slabby sandstone fragments of local bedrock. The exact relationship of the numerous low level terraces to one another and hense the relative age of their soils could not be determined in the time available.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soil/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount ($<$ 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophosphate extraction
VC	Very coarse sand 2-1 mm; C coarse sand 1-0.5 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class:	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam; silty clay loam.
+	Calcium-Dolomite ratio

Archimedes Ridge
Selected Edaphic Characteristics

Soil Profile	depth (cm)	horizon	color	% organic carbon	Exchangeable Cations Meq/100 g Ca+	Mg	K	Fe(%) DC	OX	SP	Al(%) DC	OX	SP	pH	VC	C	M	F	VF	T	C	F	C	F	Text Class
81.1	1-8	A1	10YR2/2	8.2	8.0	3.7	0.43							5.8	7	4	2	6	7	26	22	22	19	13	CL
	8-28	A12	10YR3/2	3.5	17.0	4.2	0.03	1.55	1.03	0.20	0.22*	0.20	0.10	7.1	17	7	3	6	7	40	20	18	14	9	L
	28-30	B2	10YR3/3	1.4	1.4+	-	-	1.86	0.23	0.08	0.12	0.78	0.03	8.1	16	12	6	10	9	52	16	18	11	4	L
81.9	0-6	C1	10YR4/2	1.4	5.0	2.7	0.16	1.75	0.09	0.03	0.13	0.03	0.01	6.7	5	3	1	9	8	26	17	45	11	2	SIL
	6-14	C2	10YR4/2	1.3	5.4	3.1	0.17	1.87	0.10	T	0.13	0.04	0.005	6.7	8	3	1	8	7	27	15	43	13	2	SIL
	14-50	C3	10YR4/2	1.4	6.8	3.3	0.22	1.84	0.12	0.05	0.15	0.05	0.02	7.4	3	3	1	6	6	20	15	49	14	3	SIL
	50-60	IICA	10YR3/1	1.9	8.7	4.5	0.35	2.12	0.15	0.04	0.19	0.07	0.02	7.2	4	6	2	5	5	21	13	34	27	6	CL
81.10	0-4	A1	10YR2/1	21.1										6.2	1	1	1	22	9	33	36	19	9	2	SIL
	4-10	B1	10YR3/2	9.0										5.6	2	2	3	35	16	57	18	13	7	5	FSL
	10-25	B21	10YR3/2	5.1	5.2	2.3	0.19							5.8	4	3	3	38	17	64	16	10	6	4	FSL
	25-45	B22	10YR3/3	4.1	6.7	2.2	0.16	0.96	0.26	0.21	0.25	0.13	0.15	6.3	2	2	3	39	18	62	15	11	7	5	FSL
	45-60	C1	10YR3/3	1.9	2.5	1.4	0.08	1.02	0.23	0.24	0.24	0.12	0.12	6.1	1	2	2	35	19	59	16	15	6	4	FSL
81.17	0-2	A1	10YR3/1	7.0	6.4+									8.6	0	T	T	T	2	3	20	76	1	1	SI
	2-18	B2	10YR4/1	2.2	7.7									8.4	0	T	0	1	13	14	44	32	9	2	SIL
	18-35	IIC1	10YR4/1	2.0	7.1									8.4	0	0	0	6	27	33	39	22	5	1	SIL
	35-64	IIIC2	10YR4/1	2.0	7.5									8.4	0	T	T	2	18	21	42	25	9	2	SIL
	64-73	IVC3	10YR3/1	1.7	6.0									8.5	1	2	2	12	19	35	32	25	6	2	SIL
81.18	0-2	O1	10YR2/2	36.8	0.8+									7.0											
	2-7	A1	10YR2/1	28.6	0.8+									6.9											
	7-13	B2	10YR3/2	2.7	11.5	2.1	0.12	1.08	0.37	0.17	0.18	0.07	0.04	6.9	12	13	7	11	8	51	21	16	7	5	L
	13-25	B3	10YR3/1	-	-	-	-	0.93	0.19	0.04	0.06	0.05	0.02	7.4	24	33	14	9	3	82	6	8	4	1	LCS
	25-60	C1	10YR3/1	-	14.8	7.1	0.13	1.79	0.59	0.57	0.36	0.29	0.25	8.0	17	34	22	14	2	88	4	5	3	1	CS
81.19	1-5	A1	10YR3/2	8.9										5.4	4	5	3	9	8	28	33	22	12	5	SIL
	5-14	B1	10YR3/3	5.8										5.4	4	4	3	8	8	27	31	24	12	6	SIL
81.20	0-3	Oe1	10YR2/2	22.9	0.7+									7.5											
	3-19	Oe1	10YR2/1	14.4	0.8+									7.5											
	19-30	IIB3	-	-										8.1	1	2	2	5	8	16	29	37	13	6	SIL
	30-43	IIC1	10YR4/1	3.0	4.5+									7.8	T	2	3	7	10	22	30	28	14	5	SIL
	85-96	IIC6f	10YR4/1	0.9	5.5+									8.2	T	3	10	32	15	60	19	15	4	2	FSL
81.23	0-9	Oe1	10YR2/1	23.9	-									6.1											
	9-23	Oe1	10YR3/2	22.4	-									6.1											
	23-25	IIB3	5Y4/1	6.7	14.8+	7.1	0.17							7.3	0	T	T	1	2	3	21	44	25	6	SICL
	25-30	IIC1f	-	5.8	1.9+									6.7	0	T	T	1	3	5	26	44	21	5	SIL
	30-41	IIC2f	-	4.0	3.7+									6.8	0	T	T	2	5	7	28	42	17	7	SIL
	41-49	IIC3f	-	5.0	2.9+									6.7	0	T	T	2	5	7	25	43	18	8	SIL
	49-59	IIC4f	-	5.8	3.1+									7.4	0	T	T	2	6	9	25	41	19	6	SIL
81.24	0-7	Oi1	10YR2/2	26.4										6.5											
	7-25	Oe1	10YR2/2	28.5										6.2											
	25-30	Oe2	10YR3/1	24.3										6.1											
	30-60	IIC1	5Y4/1	4.6	13.3	5.2	0.13							7.2	0	T	T	1	4	5	26	43	22	4	SIL
81.25	0-10	Oi1	10YR4/3	9.9										6.6											
	10-25	Oi2	10YR4/3	20.9										6.1											
	25-39	Oi3	10YR4/3	15.9										5.9											

Appendix B

Selected profile descriptions of the soils of the Archimedes Ridge area. Refer to Fig. 26, 27 and 30 and Appendix A for topographic setting and edaphic characteristics.

Site:	Archimedes Ridge, Profile 81.1	Photo BAR 44-81
Slope:	5% upper terrace	
Microrelief:	60-70 cm diameter polygonal cells	
Vegetation:	_Betula exilis_; _Empetrum_ sp.; _Dryas_ sp.; _Lupinus arcticus_; _Vaccinium uliginosum_	
Parent Materials:	Terrace gravels	
Classification:	Pergelic Cryochrept	

Depth/Horizon (cm)	
0-8 A1	Very dark brown (10YR 2/2) organic clay loam; weak medium subangular blocky structure breaking to weak fine granular structure; < 3% pebbles; fine roots common. Clear, wavy boundary.
8-28 A12	Very dark greyish brown (10YR 3/2) loam; fine granular structure; 15% pebbles < 1 cm; 40% pebbles 1-10 cm; continuous, thin silt coats on top of larger fragments; carbonates on under side. Clear, wavy boundary.
28-50 B2	Dark brown (10YR 3/3) loam; fine weak subangular blocky structure; coarse fragments 60%; continuous silt coats on upper surface. Profile terminated.

Site:	Archimedes Ridge, Profile 81.9	Photo BAR 44-81
Slope:	0%	
Microrelief:	Crest of outcrop. Large nonsorted circles/polygons 1-3 m (individual on crest coalesing to stripes on slope). Total microrelief 30-40 cm.	
Vegetation:	Few patches of Dryas sp. and grass. Salix phlebophyla in centers; slabby sandstone fragments, many nearly covered with lichens. Intercircle depressions have Arctostaphylus sp; Betula sp. moss; Dryas sp. some Salix sp. and Empetrum nigrum.	
Classification:	Pergelic Cryorthent	
Depth/Horizon: (cm)		
0-6 C1	Dark greyish brown (10YR 4/2) silt loam; massive; vesicular structure (vesicules < 1/2 mm) smooth inner surfaces; patches of very dark grey (10YR 3/1) fine sandy loam; 25-30% fragments mostly < 3 cm; thick continuous silt coats; few roots. Abrupt, wavy to ruptic boundary.	
6-14 C2	Dark greyish brown (10YR 4/2) silt loam; loose; slightly vesicular; 70-80% fragments 1-2 cm; medium to thick (1-2 cm) silt coats. Abrupt, smooth to wavy boundary.	
14-50 C3	Dark greyish brown (10YR 4/2) silt loam; vesicules have smooth shiney intersurfaces; 50% fragments 5-10 cm; thick silt coats bottom and top of fragments.	

Site:	Archimedes Ridge, Profile 81.17 Photo BAR 44-81
Slope:	0%
Microrelief:	Old point bar deposits
Vegetation:	Salix alaxensis (40-60 years old) Astrogalis sp.; Drepanocladus sp.; scattered Arctostaphylus sp.
Remarks:	Area aperiodically inundated
Classification:	Pergelic Cryofluvent
Depth/Horizon: (cm)	
3-0	Living mat
0-2 A1	Very dark grey (10YR 3/1) silt; weak fine granular structure; few fine roots. Clear, smooth boundary.
2-18 B2	Dark grey (10YR 4/1) dark greyish brown (10YR 4/2 rubbed); silt loam; weak medium subangular blocky structure; lenses of fine sand and few lenses (< 2 mm) of very dark grey (10YR 3/1) organic material, few roots and Salix stems. Clear, smooth boundary.
18-35 IIC1	Dark grey (10YR 4/1) silt loam; few patches of dark greyish brown (10YR 4/2) loam; discontinuous lenses to 2 mm of organic material separated by mineral (7-9 mm). Gradual, smooth boundary.
35-64 IIIC2	Dark grey (10YR 4/1) silt loam; stratified; discontinuous organic lenses (10YR 3/1) up to 5 mm; weak fine platy structure; few roots. Abrupt, smooth boundary.
64-73 IVC3	Very dark grey (10YR 3/1) to dark grey (10YR 4/1) inter-stratified very fine sandy loam and silt loam; massive few roots. Permafrost. 18 August 78.

Site:	Archimedes Ridge, Profile 81.18 Photo BAR 44-81
Slope:	0%
Microrelief:	River bar deposit. First terrace.
Vegetation:	Dryas sp. scattered Lupinus arcticus; coverage ~ 100%.
Classification:	Pergelic Cryorthent
Depth/Horizon: (cm)	
0-2 O1	Very dark brown (10YR 2/2) sapric organic; matted; many fine roots. Abrupt, smooth boundary.
2-7 A1	Black (10YR 2/1) sapric organic; very weak fine granular structure; ~ 5% fine pebbles; many fine roots. Abrupt, smooth boundary.
7-13 B2	Very dark greyish brown (10YR 3/2) loam; weak fine granular structure; coarse fraction 35% (25% < 4 cm) few cobbles to 15 cm; thin patchy silt coats; thin patchy carbonates and iron staining; many fine roots. Abrupt, wavy boundary.
13-25 B3	Very dark grey (10YR 3/1) loamy coarse sand; gravel fraction 40% with 50% of pebbles < 3 cm; loose patchy carbonates on lower surfaces of fragments; roots common. Gradual, smooth boundary.
25-60 C1	Very dark grey (10YR 3/1) to dark grey (10YR 4/1) coarse sand; gravel fraction 40%, range to 15 cm diameter; loose; discontinuous carbonates; no iron staining. Profile terminated.

Site:	Archimedes Ridge, Profile 81.19	Photo BAR 44-81
Microrelief:	Crest of high level terrace II	
Slope:	~ 0%	
Vegetation:	Lichens; moss; <u>Salix</u> sp; <u>Dryas</u> sp.	
Classification:	Pergelic Cryochrept	

Depth/Horizon:
(cm)

1-0	Vegetation mat
0-1 O1	Very dark brown (10YR 2/2) sapric organic; loose. Clean, smooth boundary.
1-5 A1	Very dark greyish brown (10YR 3/2) organic silt loam; weak fine granular structure; 15% pebbles; many roots. Abrupt, smooth boundary.
5-14 B1	Dark brown (10YR 3/3) silt loam; weak fine subangular blocky structure; 25% pebbles 20% of which are < 3 cm; silt coats on tops of fragments; no iron or carbonate coats, fine roots common. Clear, wavy boundary.
14-25 B3	Dark greyish brown (10YR 4/2) silt loam; moderate, medium subangular blocky structure; breaks to weak medium subangular and fine angular blocky structure; coarse fraction as in B1; continuous silt coats; iron coats on lower sides of fragments; few fine roots. Gradual, smooth boundary.
25-40 C1	Dark greyish brown (10YR 4/2) silt loam; weak medium angular blocky structure; 20% of coarse fraction < 3 cm; some pebbles to 10 cm. Profile terminated.

Depth/Horizon: (cm)	When silt coats are removed from bottom of fragments a clean shiney patina is left. Abrupt, wavy boundary.
50-60 IICA	Grey (10YR 3/1) clay loam; massive; nonvesicular filling between fragments; approximately 80% fragments mostly < 5 cm; 20-30% of which are < 1 cm and are included with matrix; slickensides and shiney flow structures present. Abrupt, wavy boundary.
$60\text{-}64^{+}$ C5/R	Grey (10YR 3/1) clay loam; very little matrix; few coats. Bedrock?

Site:	Archimedes Ridge, Profile 81.24	Photo BAR 44-81
Microrelief:	Strangmoor (flark) on intermediate low terrace	
Slope:	~ 0%	
Vegetation:	Carex aquatilis	
Remarks:	Palsas nearby	
Classification	Hemi-Histic Pergelic Cryaquept	

Depth/Horizon:
(cm)

0-7 Oi	Very dark brown 10YR 2/2 broken face), very dark greyish brown (10YR 3/2 crushed) coarse fibrous organic; ~ 20% very fine sand; roots common. Clear, smooth boundary.
7-25 Oe	Very dark brown (10YR 2/2 broken face), dark brown (10YR 4/3 crushed); medium fibrous sedge peat; breaks down easily; fine, live roots abundant. Abrupt, smooth boundary.
25-30(37) BC	Very dark grey (10YR 3/1) to very dark greyish brown (10YR 3/2 broken face) medium fibrous hemic peat; breaks down easily; 70% silt loam mineral. Abrupt, smooth boundary.
30-60 C1	Dark grey (5Y 4/1) silt loam; scattered organic fragments; few fine roots. Permafrost 19 August 1978.

Site:	Archimedes Ridge. Profile 81.20 Photo BAR 44-81
Slope:	< 1%
Microrelief:	First low level terrace ~ 2 m above present Utukok River.
Vegetation:	Salix spp., Sphagnum sp., Carex aquatilis.
Classification:	Pergelic Cryaquept
Depth/Horizon: (cm)	
0-3 Oe1	Dark reddish brown (10YR 2/2) hemic organic; matted; mildly alkaline; many fine roots. Abrupt, smooth boundary.
3-19 Oa1	Black (10YR 2/1) sapric organic (10YR 2/2) matted; many fine roots. Abrupt, wavy boundary.
19-30 IIB3	Dark grey (10YR 4/1) silt loam; massive; weak, fine, brown (10YR 4/3) mottles; roots common; 2-5% enmixed black (10YR 2/1) sapric organic. Abrupt, smooth boundary.
30-43 IIC1	Dark grey (10YR 4/1) silt loam; massive; wet; few fine roots. Permafrost 19 August 1980.
43-57	Ice-rich grey silty clay; with 1/2 cm thick ice lens; enmixed organic.
57-65	Organic with some mineral. 1/4 cm ice lens in mineral material.
65-78	Grey silt loam with horizontal ice lens up to 1 mm in thickness that become oblique in lower few centimeters; a few organic fragments.

Depth/Horizon: (cm)	
78-85	Grey silt loam with 50 to 66% ice lenses that are very fine and discontinuous 1/2 to 2 cm in thickness.
85-96	Grey sandy loam; 15-25% lenticular ice lenses decreasing in volume with depth.
96+	Medium gravel. Core terminated.

Site:	Archimedes Ridge. Profile 81.10 Photo BAR 44-82
Slope:	1%
Microrelief:	Crest of pyrimidal shaped ridge formed in siltstone of the Kukpowruk formation.
Vegetation:	<u>Dryas</u> sp.; <u>Arctostaphylos</u> sp., lichens and mosses.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-4 A_1	Black (10YR 2/1) organic silt loam; weak very fine granular structure; many fine roots. Abrupt, smooth boundary.
4-10 B_1	Dark reddish brown (10YR 3/2) fine sandy loam; very weak fine granular structure; friable; black (10YR 2/1) organic coats on ped faces; many fine roots. Clear, smooth boundary.
10-25 B_{21}	Dark reddish brown (10YR 3/2) flaggy fine sandy loam; weak medium subangular blocky structure parting to weak very fine subangular blocky structure; 20% fine fragments $<$ 5 cm and 20% coarse fragments 5-35 cm diameter; many fine roots. Abrupt, smooth boundary.
25-45 B_{22}	Dark reddish brown (10YR 3/3) flaggy fine sandy loam; weak medium subangular blocky structure parting to weak very fine subangular blocky structure; 40% coarse fragments 2-35 cm in diameter. Gradual, smooth boundary.
45-60 C	Dark reddish brown (10YR 3/3) flaggy fine sandy loam; very fine granular structure; 45% total coarse fraction with 20% $<$ 5 cm and 25% 5 to 35 cm in diameter. Profile terminated.

Site:	Archimedes Ridge. Profile 81.23 Photo BAR 44-81
Slope:	0%
Microrelief:	Peat plateau approximately 0.5 m high, 5 m wide and 20 to 30 m long. First low level terrace.
Vegetation:	Betula sp., moss understory, scattered Salix sp.
Classification:	Histic Pergelic Cryaquept
Remarks:	Materials below permafrost table collected with power auger.
Depth/Horizon: (cm)	
0-1 Oil	Dark yellowish brown (10YR 4/4) fibric organic mat composed of dead moss. Abrupt, smooth boundary.
1-9 Oal	Black (10YR 2/1) sapric organic; weak fine granular structure. Abrupt, wavy boundary.
9-23 Oel	Very dark greyish brown (10YR 3/2) hemic organic; matted layers 2 cm thick; fine roots common. Abrupt, smooth boundary.
23-25 B3	Dark grey (5Y 4/1) silty clay loam; massive; few roots. Abrupt, smooth boundary.
(25+)	Permafrost and mineral soil observed as follows:
25-41	Massive lens ice with vertically oriented bubbles; horizontal ice lens to 3 cm; silt loam mineral; 80% ice.
41-49	Same as 25-41 but with 75% ice.
49-59	Grey silt loam; 60-70% ice; lenses up to 1 1/2 cm thick.

Depth/Horizon: (cm)	
59-68	Ice lenses 50% of total volume with organic material, including stems.
68+	Medium gravel. Core terminated.

Site:	Archimedes Ridge. Profile 81.25 Photo BAR 44-81
Slope:	0%
Microrelief:	Abandoned meander of Utukok River approximately 3m above present stream.
Vegetation:	_Eriophorum augustifolium_; _Carex aquatilis_ with scattered _Salix_ sp.
Classification:	Pergelic Cryohemist
Depth/Horizon (cm)	
0-10 Oi1	Dark brown (10YR 4/3) fibric organic strongly matted with _Carex_ stems and roots; mineral fraction about 50%. Clear, smooth boundary.
10-25 Oi2	Dark brown (10YR 4/3) fibric organic; approximately 25 mineral included. Gradual, wavy boundary.
25-39 Oi3	Dark brown (10YR 4/3) fibric organic with dark grey (10YR 4/1) silt loam mineral; mineral content (35%); increases immediately at contact with permafrost. Abrupt, smooth boundary.
39+	Permafrost; some enmixed organic continues into frozen mineral materials.

Knifeblade Ridge Site

Physical Geography

Geology

The Knifeblade Ridge site like those at Archimedes Ridge and Sagwon is situated in the Arctic Foothills physiographic province (Wahrhaftig, 1965) but in the southern section of the province (Figs. 1 and 31). Structurally the Knifeblade Ridge site and the surrounding area, especially that to the east, appears to be an extension of the parallel anticlines and synclines that characterize the Archimedes Ridge region. Knifeblade Ridge itself (Fig. 32) is the apex of a faulted anticline and is composed primarily of a resistant light grey fine grained sandstone, the Grandstand Formation (Brosgé and Whittington, 1966). Shales of the Torok Formation (the extensive slope forming unit at Archimedes Ridge) crop out in a narrow band for a distance of slightly over 5 km along the apex of the ridge west from a presumed cross-cutting fault, Fig. 33. The broad slopes leading away from the ridge are composed of relatively soft shales of the Killik Tongue of the Chandler Formation. Discontinuous outcrops of interbedded fine grained sandstone are common to the slopes - a coal prospect (Fig. 38) is associated with one such outcrop.

Topography and surface characteristics

The Knifeblade Ridge site is some 50 km south of the southern boundary of the coastal plain. Over this distance elevations rise from approximately 95 m to between 400 and 485 m along the ridge itself. Probably one of the most striking topographic patterns within the region generally is the fine dendritic drainage and the well developed parallel and subparallel pattern of the higher order tributaries draining the upper reaches of the long

Fig. 31. Knifeblade study area(small square) with respect to regional topography. Physiographic boundary between Northern and Southern sections of the Foothills Province (Wahrhaftig, 1965) is shown by broken line. Coastal plain province boundary lies approximately 60 km to the north of Knifeblade Ridge. Large square delineates area covered in Figure 33. Arrow marks photo point for Figure 32.

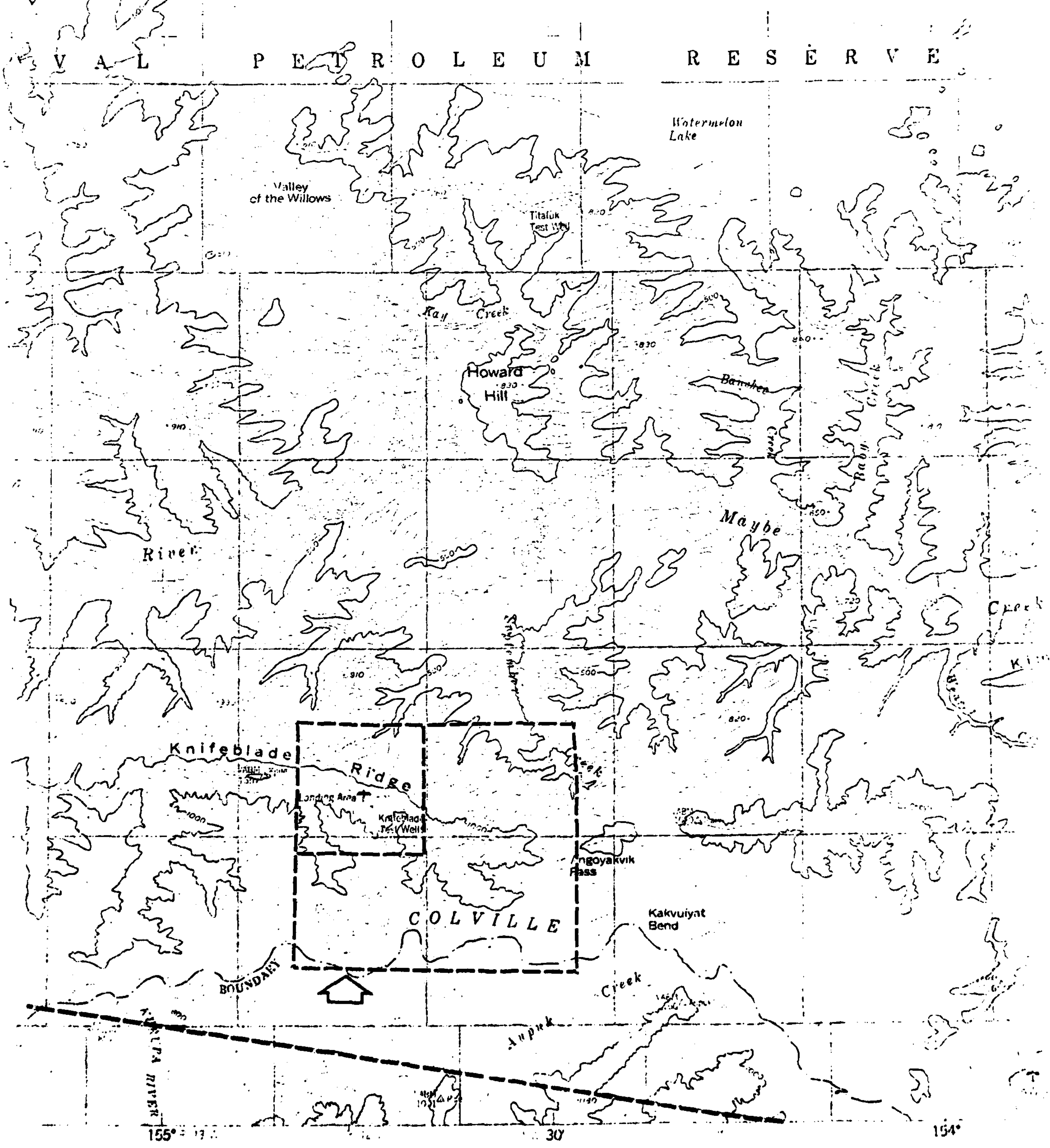


Fig.32. Knifeblade Ridge and surrounding terrain (underlain by shales of the Killik Tongue of the Chandler Formation) viewed from south side of the Colville River. U.S.G.S. photo. COL-OV-45-7

Fig.33. Knifeblade Ridge and probable cross-cutting fault are seen in the upper left part of photograph surrounded by boundaries of study area (see Fig. 31). Clearly seen is the dentritic drainage with parallel and subparallel high order tributaries draining the shale slopes. Colville River together with its flood plain and terraces is seen in lower one-third of photograph. Vehicle trains (v) dating from the late 1940's and coal prospect (CP) are indicated. NASA JSC 364 (15-317) July 1977.

shale slopes (Fig.33). In a few instances the ridge has been breached by shallow channels draining toward the Colville. The overall drainage is characteristic of the entire belt of folded Cretaceous sediments north of the Brooks Range.

A portion of the crest of Knifeblade Ridge toward its eastern end was smoothed in the late 1940's to provide a landing site for aircraft in support of the test wells being drilled at that time. Use of the surface continues on an intermittent basis. Ungraded areas on this ridge are sites of low discontinuous outcrops of near vertically dipping sandstones and well developed, small, stone bordered polygons (Fig.34). These features become extended into stripes along the shoulders of the ridge where slope increases to 10%. They continue into wet tussock tundra for a short distance before the lower angle tussock tundra slope is encountered.

On the north side of the narrow crest and for a short distance down slope frost scars and stripes are developed in silty clay loam derived from shales of the Torok Formation. Below this zone well developed solifluction lobes up to .6 m relief occur on tussock tundra slopes. Frost scars occupy up to 50% of the surface, many are surrounded by rings of large tussocks. Sandstone fragments protrude above the surface, especially from over-steepened solifluction lobes. Piping such as that described from similar slopes at Archimedes Ridge also occurs. The sandstone fragments were probably derived mostly from the ridge top and have become enmixed with mobile, silty clay loam. This portion of the slope is prone to earth flow (Fig.35).

Most of the regional slopes in the area are underlain by shales of the Chandler Formation (Killik Tongue) and except for discontinuous, narrow

Fig. 34. Small (1-2 m) diameter rock bordered circles on crest of Knifeblade Ridge.

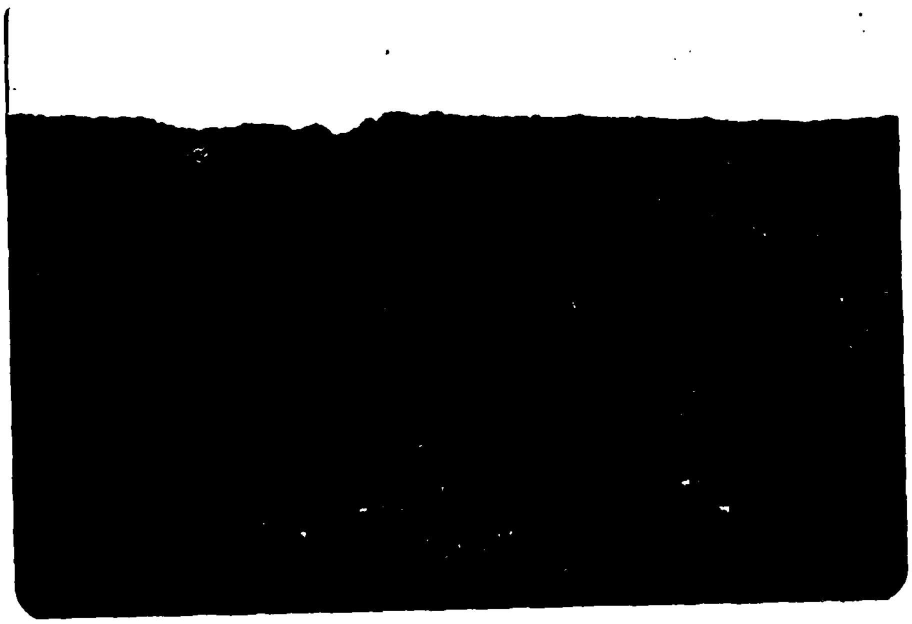


Fig. 35. Earthflow typical of those along upper debris slopes bordering Knifeblade Ridge. Such areas can become sites of channelized erosion.

outcrops of coarse sandstone and pebble conglomerate are long and uniform Tussock frost scar tundra dominates. Polygonal patterns are absent. Divides are rounded and commonly the sites of shattered rock outcrops.

Many of the second and/or third order drainages have complex longitudinal profiles that display what appears to be cut and fill sections i.e., in certain segments bedrock is exposed in the stream bed 3 to 7 m below the surrounding slope surface. Commonly these sections terminate abruptly in a thick section of fill material composed of silt, clay, fine sands and occasional sandstone flaggs. The surface of such sections may be slightly convex or only gently sloping and have Carex marshes, Fig. 36. Water enters the cut part over a series of waterfalls. Above the fill section the stream is actively cutting headward, commonly through fill material. The fill materials are colluvium in part the product of the headward eroding stream and in part solifluction and debris slide materials originating from and adjacent to the eroding channel.

Permafrost

The Knifeblade Ridge region lies within the zone of continuous permafrost (Ferrians, 1965). Seasonal thaw ranges between 25 and 65 cm depending upon the site although ice rich permafrost probably occurs at depths considerably greater than 1 m in outcrop areas. The characteristics of the near surface permanently frozen sediments is similar to other foothills areas. Evidence for massive ground ice in the form of ice wedges is generally lacking except in areas of terraces and alluviam adjacent to some of the principal rivers and in the headwaters area of the Ikpikpuk River north of the study site. Perhaps one of the clearest forms of evidence for wedge ice are the thermokarst pits associated with off road vehicle trails east of

the ridge. However, even these are not nearly so extensive as similar features at Sagwon.

Vegetation

The vegetation of the Knifeblade Ridge area is predominately a tussock (Eriophorum vaginatum) community typical of the foothill region generally (Fig.36). Of interest are two species not found (by the author) at other map sites in the Foothills, Spiraea beauverdiana(?) and alder (Alnus crispa?). Both species appear to be at or very near the northern limit of their distribution in this region. The Spiraea occurs within the tussock community while the alder occurs in a widely scattered groups commonly associated with outcrops and areas of intense frost heave activity. Arctogrostis sp. appears in isolated dense stands, again in areas of intense frost heave and bare soil.

Carex fens are small and confined to nearly level valley heads e.g., area of Test Well # 1 and in fill reaches of drainage channels (Fig.36). The willow, Salix alaxensis occurs at the disturbed (bladed) area at the coal prospect (Fig.38) but is otherwise not common in the immediate area of Knifeblade Ridge - it is abundant on terraces bordering the larger rivers e.g., the Colville and Ikpikpuk.

Soils

Soils of the Knifeblade Ridge area are generally representative of the southern foothills section of the foothills province north of the Brooks Range stretching westward from the Toolik-Sagwon area to Cape Thompson. Pergelic Cryorthents or Cryochrepts characterize the ridge top and the sporadic outcrops of fine gravelly sandstones (grits) that occur on the long tussock dominated slopes. Soils of these slopes are, with few

Fig. 36. Tussock-frost scar association on the upper steeper slope elements adjacent to Knifeblade Ridge. Solifluction lobe is visible at left center. Willow and Lupine are common associates of the vegetation community of such mobile slope elements (Fig.35).

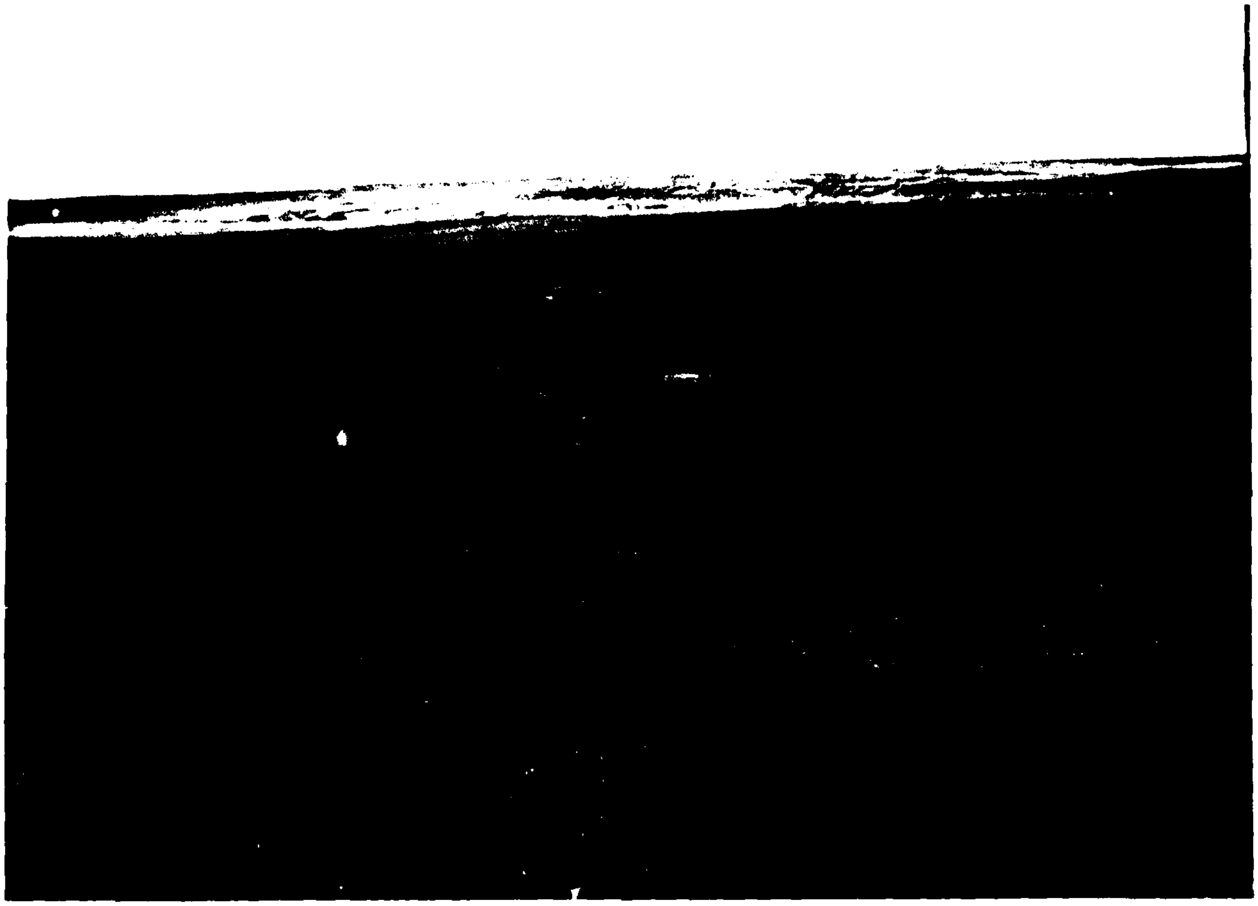


Fig. 37. View to the north down channel of cut and fill type drainage. Bluffs adjacent to Maybe Creek and the region immediately below skyline are composed of nearly flat lying rocks of the Prince Creek Formation. Slopes in foreground are underlain by Chandler Formation rocks. Letters C and F designate cut and fill reaches within drainage. Typical alder community is marked by arrow.

Fig. 38. Salix alaxensis and Salix sp. growing on alkaline spoil materials adjacent to a coal prospect established in the early 1950's. Coal may have been used in conjunction with the exploratory oil well site at the head of the valley.

exceptions Pergelic Cryaquepts and Histic Pergelic Cryaquepts. Mineral horizons are most commonly silty clay loams reflecting the predominance of shale parent materials.

Because the area is nearly all in slope Histosols are not represented although they probably occur in the broad poorly drained valley of Maybe Creek some 13 km to the north. Soils tentatively classified as Aeric Pergelic Cryaquepts occur sporadically on the tussock slopes and are usually characterized by intensive frost action. Stands of alder and *Arctagrostis latifolia* are common associates of these soils.

Typically the well drained soils display little profile differentiation below the A1 horizon. This coupled with their sandy textures and high proportion of coarse fragments dictates placement within the order Entisols as Pergelic Cryorthents (Profiles KNI 7 and 8 and Figs.39 and 40). Where they occur with patterned ground well drained soils occupy the higher elements e.g., the ridges of strip patterns. Soils occupying slight depressions associated with the higher elements show signs of wetness, principally in the form of faint higher chroma mottles rather than predominantely grey colors. Beyond this there is little on which to separate components of the pedon. Ridge crest or positions near the crest are also sites of other soils with little differentiated profiles, e.g., KNI 26 and 27. These soils are presently classified as Cryaquepts (Inceptisols) but on the basis of their morphology and chemical differentiation (only slight oxidation serves to define the B horizon) they more properly belong to the Entisols. Mottling is not present and the grey colors of the C horizon are those of the parent shale.

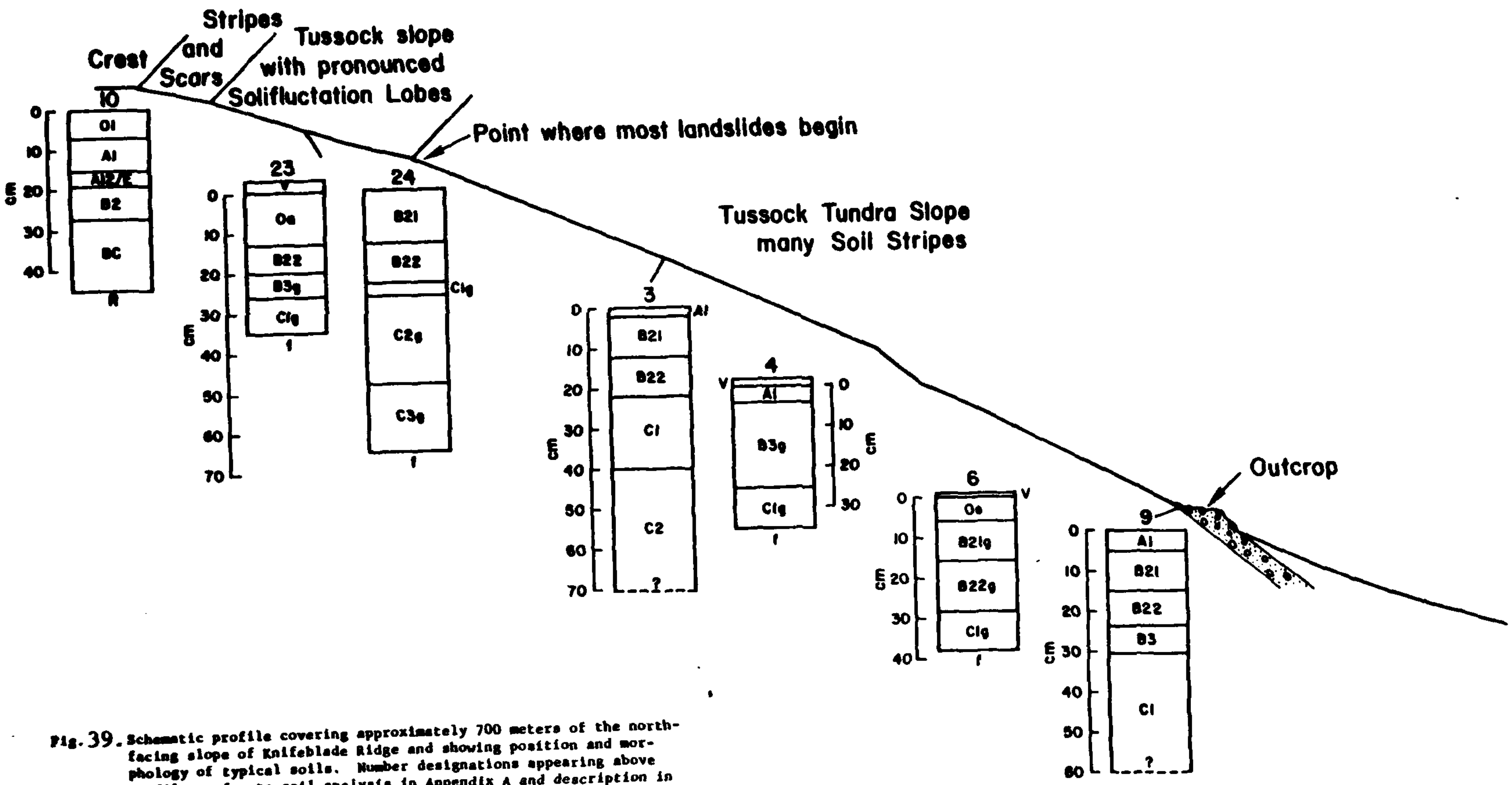


Fig. 39. Schematic profile covering approximately 700 meters of the north-facing slope of Knifeblade Ridge and showing position and morphology of typical soils. Number designations appearing above profiles refer to soil analysis in Appendix A and description in Appendix B.

Fig. 40. Pergelic Cryochrept developed near the crest of Knifeblade Ridge. Profile shows little differentiation (compare with Atigun Canyon Profile 3342). Note high proportion of coarse skeletal material and root distribution in this well drained, relatively warm soil.

Soils best described as Pergelic Cryochrepts are represented by profile KNI 9. This and similar soils have formed on discontinuous outcrops of poorly graded sandstone or grit. Although chemical analyses were not conducted such soils normally have very low levels of exchangeable cations and a small exchange complex, i.e., little organic and/or clay content (Appendix A). The E horizon sometimes identified with such well drained sandy soils missing in KNI 9.

The great majority of soils within the Knifeblade Ridge area are Pergelic Cryaquepts, and as is typical of tussock tundra they have complex profiles (Figs. 41 and 42). However unlike so many other tussock tundra soils Histic epipedons are relatively few unless the tussock itself is included as part of the profile, a suggestion put forth in previous sections of this report. The complexity of profile morphology is probably a reflection of the great instability of the surface. This interpretation is supported by the clay mineral suite which is constant with depth and dominated by well crystallized primary minerals. Radiocarbon dated material from the permafrost surface was only 1380 y B.P. a very young date when compared to similar materials from more stable surfaces e.g., Sagwon or Toolik and attests to the instability of the tussock surface.

In general the tussock tundra slopes have from 10 to 30% active frost scars. In certain areas, however, frost scar activity reaches 50% or more. In addition to the high degree of surface instability the red color of the mineral soil and the common association of alder and the grass (Arctagrostis) serve to characterize sites of Aeric Pergelic Cryaquepts of which Profile KNI 6 is typical. It is not certain why these sites are so unstable. The limited analysis suggests a somewhat

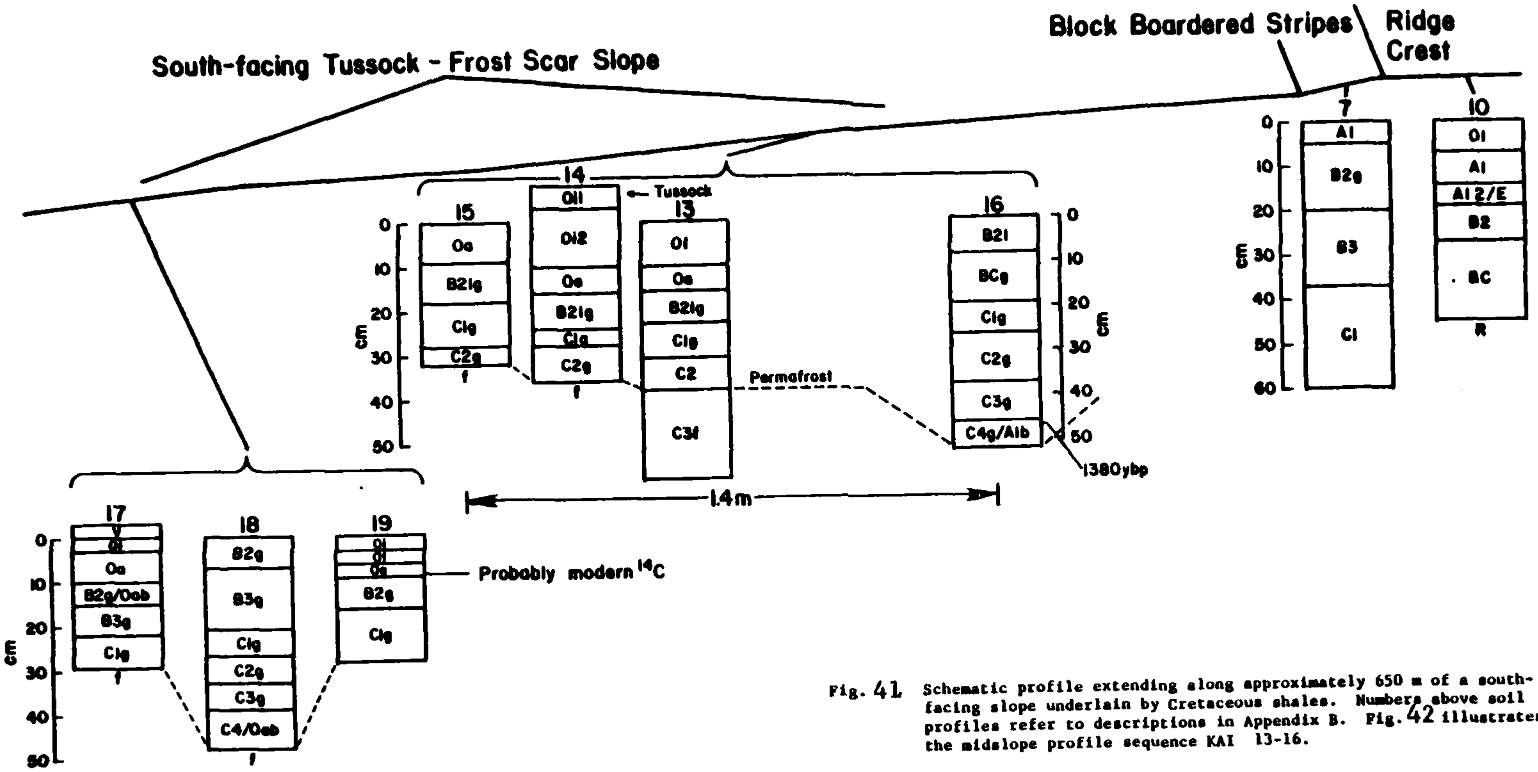


Fig. 41 Schematic profile extending along approximately 650 m of a south-facing slope underlain by Cretaceous shales. Numbers above soil profiles refer to descriptions in Appendix B. Fig. 42 illustrates the midslope profile sequence KAI 13-16.

Fig. 42. Range in morphological complexity of Pergelic Cryaquepts developed on tussock tundra slope. This series is similar to the profile sections shown in Fig.39 and represents a linear distance of 1 m. All profiles except frost scar on fore left are to permafrost as of 24 August 1978.

higher content of silt than is typical of the Pergelic and Histic Pergelic Cryaquepts. This however, needs to be further established. The association with alder is by no means universal but, as at other sites (Tramway Bar, Bonanza Creek) alder is a common associate of naturally disturbed sites.

Chemically the Aeric Pergelic Cryaquepts appear to have lesser amounts of exchangeable calcium and magnesium than other soils studied at the site. Iron, however is very abundant either in crystalline amorphous or complexed forms. In fact the values for KNI 6 are the highest recorded at any site. This is especially so with both pyrophosphate extractable iron and aluminum. Aluminum in either crystallized or amorphous forms does not appear to be significantly different from that in other different soils.

The large amounts of iron and aluminum are probably artifacts from the bedrock parent materials. The considerable mixing of the soils may account for the quantities of both elements complexed with organic compounds.

Landscape Evolution

The soil landscape of the Knifeblade Ridge area is generally typical of the southern section of the Arctic Foothills. It has not been glaciated. The major topographic elements have been produced by differential erosion of folded cretaceous sediments, primarily shales and sandstones or grits, the latter forming ridges. The broad uniform slopes are the products of mass movement, mostly solifluction, of the easily weathered shales. Movement appears to be rapid enough in many cases to close off portions of drainageways and produce the stepped longitudinal profiles shown in Figure 7 and to override portions of sandstone outcrops. Solifluction is also active on the steeper portions of slopes where it is commonly supplemented by earth flow.

The great instability in what is probably a rather thin veneer of silt loam and silt clay loam does not permit the development of persistent soil horizons. The limited ^{14}C dating of buried organic matter indicates the soil landscape at any given point is probably less than 2000 years old and probably much younger. This is similar to the Archimedes Ridge area and to a lesser extent Cape Thompson as well, but is in contrast to Sagwon and Toolik where less frost susceptible materials result in a more stable (older) soil landscape.

Only on sandstone supported ridge tops or sandstone (grit) outcrops on slopes is there sufficient stability to permit soil profile differentiation in the relatively well drained materials. Even though morphological differentiation of these soils suggests the processes of Podzolization are operating their chemical differentiation is only rudimentary. This is due mostly to the low soil moisture regime, scanty vegetation cover (and organic component necessary for the production of organic acids). Although the sites are considered stable by comparison to the shale slopes there is probably sufficient instability due to deflation to present much profile differentiation. With respect to chemical differentiation in well drained profiles, those at Archimedes Ridge developed in gravels far exceed the Knifeblade Ridge soils.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soil/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount ($<$ 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophosphate extraction
VC	Very coarse sand 2-1 mm; C coarse sand 1-0.5 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class:	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam; silty clay loam.
+	Calcium-Dolomite ratio

Knifeblade Ridge
Selected Edaphic Characteristics

Soil Profile[5]	Depth (cm)	Horizon	Color[4]	% Organic carbon	Exchangeable Cations Meq/100 g Ca^{++}	Mg^{++}	K^{+}	Fe(%) DC	OX	SP	Al(%) DC	OX	SP	pH	Particle Size Distribution: Sands 2-0.05µm VC	C	M	F	VF	T	Silt (µm) 50-20 C	20-2 F	Clay (µm) 2-.2 C	<.2 F	Text Class
8	0-5	A1	10YR3/2	24.6	-	-	-							5.7[2]	-	-	-	-	-	-	-	-	-	-	
	5-19	B21g	10YR4/3	1.7	8.2	3.3	0.09	1.9	0.5	0.1	0.21	0.17	0.09	6.4	3	4	5	47	9	67	10	14	8	2	FSL
	19-40	B3g	10YR3/3	-	9.1	4.6	0.17	-	-	-	-	-	-	8.0	1	2	3	38	11	55	14	15	12	4	FSL
	40-52	C1	10YR3/3	-	8.5	4.3	0.13							7.3	2	4	4	43	10	63	12	13	9	3	FSL
7	0-5	A1	10YR3/2					0.8	0.2	0.1	0.12	0.08	0.05												
	5-20	B21	10YR3/3					0.6	0.1	T	0.06	0.04	0.01												
	20-37	B3	10YR3/3																						
	37-60	C1	10YR3/3																						
9	0-5	A1	10YR4/3	0.8										5.1	-	-	-	-	-	-	-	-	-	-	-
	5-15	B21	10YR5/4	0.5										5.1	7	34	27	13	3	84	4	7	4	1	LCS
	15-24	B22	10YR5/6	0.4										5.1	5	32	30	15	2	85	4	5	5	1	LCS
	24-31	C1	7.5YR4/2	0.4										5.2	10	45	26	12	2	95	2	2	2	T	CS
	31-60	C2	10YR3/2	1.7										5.4	7	41	20	9	4	81	6	8	5	1	LCS
25	0-2	Oa1	10YR2/2	16.6	-	-	-							6.6	-	-	-	-	-	-	-	-	-	-	-
	2-12	Oa2	10YR3/2	8.0	5.8	4.5	0.29							5.3	1	2	3	16	7	29	27	23	15	7	L
	12-19	BC	5Y4/2	1.3	6.9	5.0	0.26							6.6	5	4	1	4	4	18	22	40	17	4	SIL
	19-26	C1	2.5Y4/2	1.3	9.8	6.8	0.42							6.9	5	3	1	1	2	11	19	38	22	10	SICL
	26-36	C2	10YR3/2	1.6	-	-	-							7.2	4	2	T	1	1	9	13	49	22	8	SICL
	36-50	C3	5Y4/1	-	-	-	-							8.1	4	3	1	1	1	9	11	48	24	9	SICL
6	0-6	Oe	10YR2/2	37.3	2.7	1.3	0.16	-	-	-	-	-	-	5.1	-	-	-	-	-	-	-	-	-	-	-
	6-16	B21g	10YR5/6	-	4.2	1.6	0.15	2.8	1.1	0.9	0.29	0.20	0.45	5.5	T	1	1	4	4	11	23	40	19	8	SIL
	16-28	B22g	10YR4/4	-	5.5	1.3	0.39	3.2	1.4	1.3	0.31	0.25	0.62	5.6	1	2	1	5	5	14	20	40	19	8	SIL
	28-38	C1g	10YR4/2	-	-	-	-	2.1	0.9	0.9	0.23	0.19	0.90	5.8	1	1	1	4	4	11	22	40	22	6	SICL
13	0-10	Oe	10YR2/1	39.0	-	-	-							5.9	-	-	-	-	-	-	-	-	-	-	-
	10-16	Oa	10YR2/1	30.4	-	-	-							6.0	-	-	-	-	-	-	-	-	-	-	-
	16-23	B21g	10YR4/2	5.5	6.5	4.2	0.20							5.5	0	T	1	5	14	20	28	24	17	13	SICL
	23-31	C1g	10YR5/1	4.5	3.7	2.5	0.21							5.2	0	T	T	5	13	19	26	25	18	13	SICL
	31-38	C2g	10YR3/1	7.5	-	-	-							5.2	0	T	1	6	12	18	25	22	21	14	SICL
16	0-8	B21	10YR3/3	3.9	5.5	4.6	0.30							5.7	0	T	1	5	14	20	26	25	17	12	SICL
	8-19	BCg	10YR4/2	4.3	-	-	-							5.2	0	T	1	5	13	19	29	22	17	13	SICL
	19-26	C1g	10YR4/1	5.5	-	-	-							5.1	0	T	1	6	12	19	24	24	17	17	SICL
	26-37	C2g	10YR4/1	6.3	-	-	-							5.1	T	T	1	5	12	18	26	22	21	13	SICL
	37-46	C3g	10YR3/1	8.7	6.1	1.9	0.65							5.0	0	T	T	5	12	18	23	25	20	15	SICL
	46-52	C4g/A1b	10YR3/1 2/1	6.7	-	-	-							5.2	0	1	2	16	12	30	18	22	18	12	CL

Appendix B

Selected profile descriptions of the soils of the Knifeblade Ridge area. Refer to Figs. 39 and 41 and Appendix A for topographic setting and edaphic characteristics.

Site:	Knifeblade Ridge KNI#3
	Stabilized stepped stripes (most inactive) approximately 1 m wide
Slope:	15%
Vegetation:	Dryas octopetala; Lupinus sp.; Equisetum arvense in interstripe areas. Stripe areas (profile) have moss, Salix sp.; Cassiope tetragona; Arctostaphylos sp.; Vaccinium uliginosum; and Salix reticulata.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-2 A1	Very dark greyish brown (10YR 3/2) organic silt loam; friable; very weak, fine granular structure; roots common. Abrupt, smooth boundary.
2-12 B21	Dark greyish brown (10YR 4/2) silty clay loam; very weak, fine platy structure breaking to strong fine subangular blocky structure; ped faces smooth and shiney; 10 to 15% angular sandstone fragments < 1 cm with occasinal fragments to 2 cm; no carbonates. Abrupt, smooth boundary.
12-22 B22	Dark greyish brown (10YR 4/2) silty clay loam; weak fine platy structure breaking to moderate fine subangular blocky structure; ped faces less shiney than in B2; shear strength 6TSF; 5-10% weathered sandstone fragments < 2cm; roots common. Clear, smooth boundary.

Depth/Horizon (cm)	
22-40 C1	Very dark greyish brown (2.5Y 3/2) silty clay loam; massive; moist; very weak fine platy structure; shear strength 4TSF*; between 22-27 cm < 5% weathered sandstone fragments > 3 cm diameter; 5 to 10% finer fragments and coarse gravel; no coatings; few roots. Clear, smooth boundary.
40-70+ C2	Very dark greyish brown (2.5Y 3/2) silty clay loam; massive; moist; shear strength 2.5TSF; < 5% fragments to 4 cm diameter; few roots; water enters pit at 55 cm. Profile terminated.

* Tons per square foot.

Site:	Knifeblade Ridge KNI#4
	Trough element 1 m from stripe (KNI#3)
	Vertical difference 20 cm.
Slope	15%
Vegetation:	See profile KNI#3
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
2-0	Living moss
0-4 A1	Very dark brown (10YR 2/2) fine fibrous organic (hemic); breaks down easily; 5-10% mineral; roots common. Abrupt, smooth to ruptic boundary.
4-25 B3g	Dark greyish brown (10YR 4/2) silty clay loam; moist; massive; 20-25% strong medium yellowish red mottles; shear strength 1.7TSF; < 2% fine fragments; roots common. Clear, wavy boundary.
25-35 C1g	Dark greyish brown (2.5Y 4/2) loam; moist; massive; discontinuous to 2 cm thick; black (10YR 2/1) sapric organic at upper boundary with weak, fine platy structure; sandstone fragments < 2% to 2 cm diameter; prominent at lower boundary; 2 to 5% weak fine yellowish brown 10YR 5/6 mottles. Permafrost.

Site:	Knifeblade Ridge KNI#6
	Interfluve areas - tussock slope of frost scars
Slope:	5%
Vegetation:	*Alnus* sp., *Betula exilis*; scattered *Salix* sp.; *Ledium palustre*.
Remarks:	Frost scars 30-40% of surface, 50% active.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
1-0	Living vegetation
0-6 Oe	Very dark brown (10YR 2/2) hemic organic (mostly moss); matted. Abrupt, wavy boundary.
6-16 B21g	Yellowish brown (10YR 5/6 moist) silt loam; weak, fine platy structure breaks to weak fine granular especially in upper 1 to 2 cm; (in frost scars structure is moderate, fine granular); common, 10-20% pale brown (10YR 6/3) mottles especially around roots (living or dead); few fine roots. Clear, smooth boundary.
16-28 B22g	Dark yellowish brown (10YR 4/4 moist) silt loam; friable; weak, fine platy structure breaking to very weak fine subangular blocky structure; common (10-15%) fine brown (10YR 5/3) mottles oriented vertically surrounding roots. Abrupt, wavy boundary.

KNI#6

Depth/Horizon (cm)	
28-38 Clg	Dark greyish brown (10YR 4/2 moist) - mixed color - silty clay loam; weak, coarse platy structure; common prominent yellowish brown (10YR 5/8) mottles and enmixtures of dark greyish brown (10YR 3/2) loam. Frost, 22 August 1978.

Site:	Knifeblade Ridge KNI#7 Stripe area transitional to tussock tundra, 5 m south of ridge crest. Stripe element.
Slope:	3%
Vegetation:	_Dryas octopetala_ (40%); _Vaccinium uliginosum_ (5%); _Lupinus_ sp. (4%); grass, _Salix_ sp. and _Empetrum_ sp. Coverage 65%.
Remarks:	See KNI#8 for interstripe element.
Classification:	Pergelic Cryorthent
Depth/Horizon: (cm)	
0-5 A1	Very dark greyish brown (10YR 3/2) loam; weak, fine granular structure; 40% gravel (4 cm) matrix. Abrupt, wavy boundary.
5-20 B2g	Dark brown (10YR 3/3) loam; weak very fine granular structure; fine, weak, dark greyish brown (10YR 4/2) mottles; ped faces have thin silt coats; thin patchy carbonates on underside of pebbles. Abrupt, wavy boundary.
20-37 B3	Dark brown (10YR 3/3) loam; weak very fine granular structure; 60% gravel fraction, 1 to 30 cm in diameter; continuous silt coats on tops of pebbles; no carbonates on gravel. Abrupt, wavy boundary.
37-60 C1	Dark brown (10YR 3/3) loam; gravel fragments 65%; continuous thin silt coats. Profile terminated.

Site:	Knifeblade Ridge KNI#8
	See KNI#7. Trough element 25 cm from KNI#7.
Slope:	See KNI#7.
Vegetation:	*Empetrum eamesii*; *Vaccinium uliginosum*; moss. Coverage 100%.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-5 A1	Very dark greyish brown (10YR 3/2) organic fine sandy loam; friable; weak, very fine granular structure; 15% pebble fraction; roots common. Abrupt, smooth boundary.
5-19 B21g	Dark brown (10YR 4/3) fine sandy loam; friable weak fine granular structure; few weak greyish brown (10YR 5/2) mottles; 60% pebble fraction with 40% < 3 cm; slightly rounded; larger fragments to 23 cm; thin patchy carbonate on bottom; continuous silt coats up; roots common. Abrupt, smooth boundary.
19-40 B3g	Dark brown (10YR 3/3) fine sandy loam; friable; weak fine granular structure; few weak fine greyish brown (10YR 5/2) mottles; coarse fraction 60%; coatings as in B21g. Gradual, wavy boundary.
40-52 C1g	Dark brown (10YR 3/3) fine sandy loam; loose; coarse fraction 85% with 60% between 5 and 30 cm diameter; mottles as in B3g. Profile terminated (bedrock).

Site:	Knifeblade Ridge KNI#9 Narrow terrace formed by outcrop of sandy pebble conglomerate surrounded by tussock tundra.
Slope:	2%
Vegetation:	<u>Dryas octopetala</u>; <u>Arctostaphylos</u> sp.; <u>Lupinus</u> sp.; widely scattered grass and <u>Betula exilis</u>. Coverage 20%.
Classification:	Pergelic Cryochrept
Depth/Horizon (cm)	
0-5 A1	Dark brown (10YR 4/3) loamy sand, loose; 70% coarse fragments 1 to 25 cm; rounded, flat, patchy silt coats on bottom of some fragments; roots common. Abrupt, wavy boundary.
5-15 B21	Yellowish brown (10YR 5/4) loamy sand, loose; 70% coarse fragments to 35 cm; approximately 20% of fragments are < 2 cm; thin black (10YR 2/1) iron coatings on bottoms of larger rock fragments; very thin patchy to continuous silt coatings on top of fragments. Gradual, wavy boundary.
15-24 B22	Yellowish brown (10YR 5/6) loamy sand, loose; 45% rounded conglomerate fragments as above; few roots. Abrupt, smooth boundary.
24-31 C1	Dark brown (7.5YR 4/2) loamy sand, loose; 70% coarse fragments as in 5-15 cm horizon. Abrupt, smooth boundary.

Depth/Horizon (cm)	
31-60+ C2	Very dark greyish brown (10YR 3/2) loamy sand; loose; 70% coarse fragments, most with silt coats on upper surface. Profile terminated.

Site:	Knifeblade Ridge KNI#10
	East end of ridge. Sorted nets translating to garlands or contour oblique terraces and eventually strips. Profile or terrace tread.
Slope:	5%
Vegetation:	_Ledum palustre_; _Arctostaphylos_ sp.; _Cassiope tetragona_. 100% cover.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-7 O1	Dark reddish brown (5YR 3/2) hemic organic; fibrous, somewhat matted; < 1% rock fragments (sandstone); roots common. Abrupt, wavy boundary.
7-15 A1	Very dark brown (10YR 2/2) sapric organic; firm; breaks to very weak fine angular blocky structure; < 1% clear (uncoated) quartz grains; < 1% sandstone fragments to 10 cm diameter; no silt coatings; thin patchy iron stains on bottom. Abrupt, ruptic to pendant boundary.
15-19 E(A12)	Very dark greyish brown (10YR 3/2) fine sandy loam; weak fine subangular structure; quartz grains uncoated. Abrupt, ruptic boundary.
19-27 B2	Dark yellowish brown (10YR 3/4 - 3/6) loam; friable; weak fine subangular blocky structure; peds somewhat shiney; 20-30% flat sandstone fragments with thin patchy silt coats; sporadic iron coats on under side; roots few. Abrupt, wavy boundary.

KNI#10

Depth/Horizon (cm)	
27-45 BC	Dark brown (10YR 3/3) fine sandy loam; very weak fine subangular blocky structure; ped surfaces rough; 20-30% flat sandstone fragments increasing with depth to 40-60% and becoming nearly vertical; few thin patchy silt coats on upper sides; few thin patchy iron coats on lower sides; few roots. Profile terminated (bedrock).

Site:	Knifeblade Ridge KNI#13
	South-facing tussock slope - intertussock area
Slope:	8%
Vegetation:	See KNI#16
Remarks:	Tussock height 22-20 cm. 50% surface has frost scars, 5% are active.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-10 Oe	Black (10YR 2/1) hemic organic, matted; coarse stems and roots abundant. Abrupt, wavy boundary.
10-16 Oa	Black (10YR 2/1) sapric organic; many live and dead roots; stems common. Abrupt, smooth boundary.
16-23 B21g	Dark greyish brown (10YR 4/2) silty clay loam; very weak medium subangular blocky structure; common, medium, distinct dark brown (7.5YR 4/4) mottles; patches of dark yellowish brown (10YR 3/4) organic. Gradual, wavy boundary.
23-31 C1g	Grey (10YR 5/1) - greyish brown (10YR 5/2) silty clay loam; massive; shear strength 1.1-1.5 TSF; common, medium, distinct dark brown (7.5YR 4/4) mottles. Clear, smooth boundary.
31-38 C2	Very dark grey (10YR 3/1 wet) silty clay loam; massive thixotropic; few _Eriophorum vaginatus_ roots. Frost. 24 August 1978.
38-58 C3f	Very dark grey (10YR 3/1) silt loam; approximately 30% ice lenses to 1 cm.

Site:	Knifeblade Ridge KNI#16
	South-facing long pediment slope with tussocks and frost scars.
Slope:	8%
Vegetation:	*Salix* sp.; *Ledum palustre*; *Cassiope tetragona*; *Betula exilis*; *Empetrum* sp.; *Salix* spp.; *Salix reticulata*; *Dactalyna arctica*; mosses.
	Salix spp. and *Betula* account for 20% of vegetation cover.
Remarks:	Active frost scar, 1.35 m from KNI#13.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-8 B21	Dark brown (10YR 3/3) silty clay loam; weak fine granular structure; shear strength 1.8 TSF; few roots. Clear, smooth boundary.
8-19 BCg	Dark greyish brown (10YR 4/2) and dark grey (10YR 4/1) silty clay loam; many (40%) dark yellowish brown (10YR 4/4-4/6) medium distinct mottles; weak medium subangular blocky structure; shear strength 1.7 TSF; common roots. Gradual, wavy boundary.
19-26 C1g	Dark grey (10YR 4/1) silty clay loam; massive; shear strength 2.6 TSF; many (20%) dark brown (7.5YR 4/4) distinct medium mottles; roots few to common. Clear, smooth boundary.

Depth/Horizon (cm)	
26-37 C2g	Dark grey (10YR 4/1) silty clay loam; weak fine platy structure breaking to weak medium subangular blocky structure; few (2%) very dark brown (10YR 2/2) mottles. Abrupt, wavy boundary.
37-46 C3g	Very dark grey (10YR 3/1) silty clay loam; weak medium platy structure; few (< 2%) large dark greyish brown (10YR 4/2) mottles; some enmixed sapric organic matter; very few live roots. Abrupt, wavy boundary.
46-52 C4g/A1b	Very dark grey (10YR 3/1 wet) clay loam; massive; patches of black (10YR 2/1) sapric organic matter; roots absent. Frost, 24 August 1978.

Site:	Knifeblade Ridge KNI#23
	Tussock, solifluction slope, north side of ridge.
	Step microtopography: step 50 cm, tussocks 30 cm.
	Tussocks 45%, intertussock 35%, frost scars and stripes 15%.
Slope:	17-22%
Vegetation:	_Lupinus_ sp., _Salix_ sp., _Vaccinium vitis-idaea_ _Arctagrostis_ sp., _Eriophorum vaginatum_; moss.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Moss mat
0-13 Oa	Black (10YR 2/1) *fibrous peat to* very dark brown sapric when rubbed; matted; shear strength 0.5TSF; > 30% mineral. Abrupt, smooth boundary.
13-20 B22g	Grey (10YR 5/1) silty clay loam; very weak medium platy structure breaking to very weak medium subangular blocky structure; 20% fine sand; common medium distinct (10YR 4/3) mottles. Abrupt, smooth boundary.
20-26 B3g	Dark grey (10YR 4/1) silty clay loam; weak medium platy structure breaking to weak medium subangular blocky structure; 20% fine sand; shear strength 1.5TSF; brown (10YR 4/3) mottles; few roots. Clear, smooth boundary.

KNI#23

Depth/Horizon (cm)	
26-35 Clg	Very dark grey (10YR 3/1) loam; massive; wet; thixotropic; < 1% rock fragments; patchy organic enmixed; few faint medium-weak dark greyish brown (10YR 4/2) mottles. Permafrost.

Site:	Knifeblade Ridge KNI#24
	Step like frost scar 130 cm east of KNI23;
	represents 5% of surface.
Slope:	< 17%
Vegetation:	Surface bare scar surrounded by tussocks (<u>Eriophorum vaginatum</u>); <u>Dryas octopetala</u>; grass; moss.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-13 B21	Grey to very dark greyish brown (10YR 3/1-3/2) silty clay loam; weak, fine platy structure breaking to moderate fine granular structure; shear strength 1.4TSF; roots common. Clear, smooth boundary.
13-23 B22	Very dark greyish brown (10YR 3/2) silty clay loam; weak medium platy structure breaking to moderate fine subangular blocky structure; roots common. Abrupt, smooth boundary.
23-26 C1g	Dark grey (10YR 4/1) silty clay loam; weak medium and fine subangular blocky structure; shear strength 2.5TSF; few medium dark brown (10YR 4/3) mottles; roots common; 3% coarse fragments. Clear, smooth boundary.

Depth/Horizon (cm)	
36-48 C2g	Very dark grey (10YR 3/1) silty clay loam; massive, shear strength 2.7 TSF; few medium faint very dark greyish brown (10YR 3/2) mottles. Clear, smooth boundary.
48-65 C3g	Very dark grey (10YR 3/1) loam; massive;shear strength 1.8 TSF; common, medium very dark greyish brown (10YR 3/2) mottles; few roots; 5% sandstone fragments. Permafrost.

Site:	Knifeblade Ridge KNI#25 North side of ridge approximately 2 m from crest. Well developed sorted nets in shale.
Slope:	2%
Vegetation:	<u>Dryas</u> <u>octopetala</u> (40% of cover), <u>Lupinus</u> sp., <u>Arctostaphylos</u> sp.; <u>Vaccinium</u> <u>uliginosum</u> on raised areas. <u>Empetrum</u> sp. and <u>Cassiope</u> <u>tetragona</u>, lichens in troughs. Total cover 75%.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	<u>Dryas</u>, moss mat
0-2 Oa1	Very dark brown (10YR 2/2) sapric organic; matted with fine live roots; weak very fine granular structure. Abrupt, smooth boundary.
2-12 Oa2	Very dark greyish brown (10YR 3/2-3/3) sapric organic loam; weak very fine granular structure; many fine live roots; horizon ranges to 16 cm thick. Abrupt, smooth boundary.
12-19 BC	Olive grey (5Y 4/2) channery silt loam; 16% coarse fraction with shale pieces less than 5 cm along longest axis and sandstone fragments up to 20 cm in diameter; shale fragments comprise about 40% of the coarse fraction; weak medium angular blocky structure; common fine live roots; medium plastic. Clear, smooth boundary.

KNI#25

Depth/Horizon (cm)	
19-26 C1	Dark greyish brown (2.5Y 4/2) silty clay loam; 10% coarse fraction consists of shale fragments; weak medium angular blocky structure; medium plastic; common fine roots. Abrupt, smooth boundary.
26-36 C2	Very dark grey (10YR 3/1) silty clay loam; 10-15% coarse fraction consisting of shale fragments; moderate medium angular blocky parting to moderate fine angular blocky structure; few live roots. Gradual, smooth boundary.
36-50 C3	Dark grey (5Y 4/1) silty clay loam; 15% coarse fraction consists of shale fragments; moderate fine angular blocky structure. Profile terminated.

Site:	Knifeblade Ridge KNI#26
	North side of ridge approximately 2 m from crest. Well developed sorted nets in shale.
Slope:	2%
Vegetation:	See profile KNI#25
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
.3-0	Moss mat
0-4 A1	Very dark brown (10YR 2/2) sapric organic, matted with many fine roots. Abrupt, smooth boundary.
4-12 B21	Dark grey (5Y 4/1) and olive grey (5Y 4/2) silt loam, 12% coarse fraction consisting of shale fragments less than 5 cm wide; weak medium angular blocky structure; many fine roots, silt coats patchy on fragments. Clear, smooth boundary.
12-23 C1	Dark grey (5Y 4/1) shaley silty clay loam; friable; 20% coarse fraction with shale fragments mostly less than 10 cm wide; weak medium angular blocky structure, fine roots common. Abrupt, smooth boundary.
23-40 C2	Dark grey (10YR 4/1) shaley silty clay loam; friable. 15% coarse fraction consisting mostly of shale; moderate fine angular blocky structure. Abrupt, smooth boundary.
40+ C3	Material is similar to that described in C above but coarse fragments increase with depth. Profile terminated.

Site:	Knifeblade Ridge KNI#27 North side of ridge approximately 2 m from crest. Well developed sorted nets in shale. Active center 25 cm higher than KNI#26.
Slope:	2%
Vegetation:	Absent
Classification	Pergelic Cryaquept
Horizon/Depth (cm)	
0-8 B21	Dark greyish brown (2.5Y 4/2) loam; friable; 15% coarse fragments of shale and sandstone up to 10 cm in width; moderate very fine granular structure; many fine live roots. Clear, smooth boundary. Top 2 cm dry.
8-23 B22	Dark brown (10YR 3/3) light silty clay loam; friable; 15% coarse fragments of shale and sandstone; moderate fine subangular blocky structure; fine roots common. Clear, wavy boundary.
23-29 C1	Dark grey (5Y 4/1) and olive grey (5Y 4/2) heavy silty clay loam; friable; 15% coarse fraction mostly shale fragments less than 15 cm in width; moderate medium angular blocky structure; few roots. Clear, smooth boundary.
29-42 C2	Dark grey (10YR 4/1) silty clay loam; friable. 17% coarse fraction, mostly shale fragments - coarse fraction increases with depth; moderate medium angular blocky structure parting to moderate fine angular blocky structure. Profile terminated. Horizon similar to C horizon in KNI#25 and 26.

Atigun Canyon Site

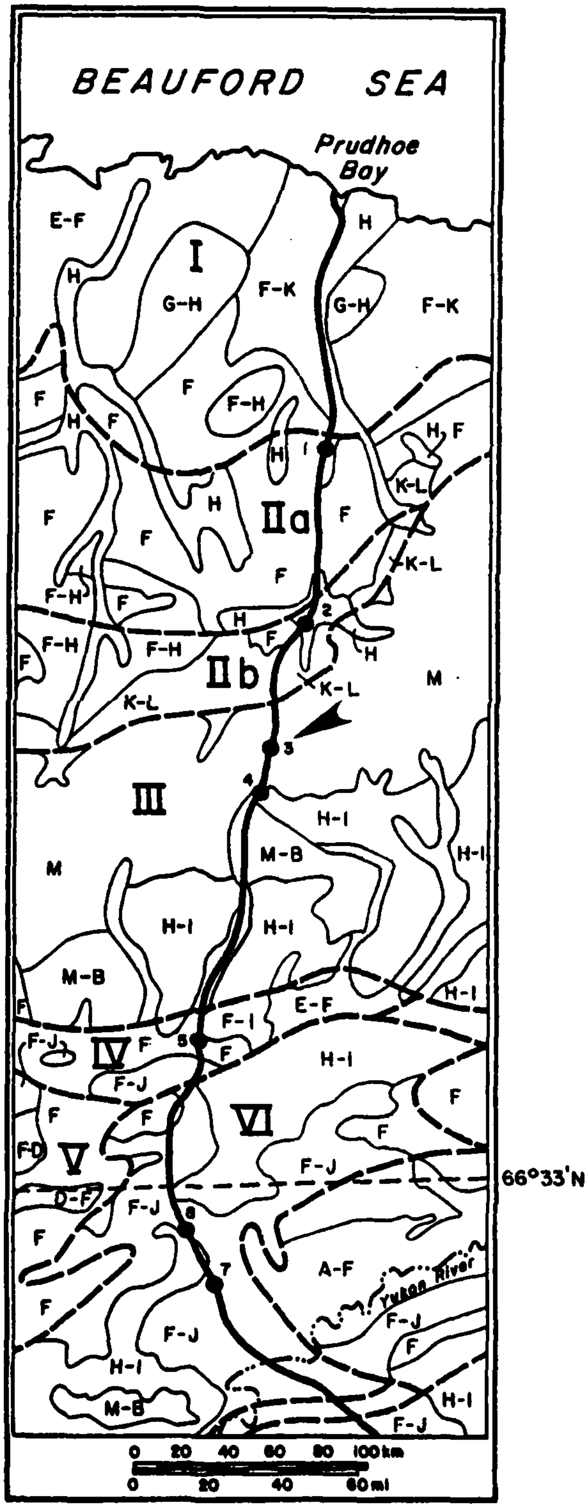


Fig. 43. Location of Atigun Canyon site (3) with respect to generalized physiographic and soils boundaries. See Fig. 10.

Physical Geography

Geology

The Atigun Valley site (designated 3 on Fig. 1) lies in the upper reaches of the eastern fork of the Atigun River approximately 250 km south of Prudhoe Bay and 6.2 km north of the Continental Divide. The area is typical of many of the larger north trending valleys in the Endicott Mountain segment of the Brooks Range.

Throughout most of its length (~ 40 km) Atigun Valley (east fork) is cut into faulted and folded, well indurated conglomerates, fissel shales, cherts and sandstones of Devonian age (Ferrians, 1971; and Beikman, 1978). Differential erosion has rendered the broader structural characteristics of the units quite visible. A little over 3 km south of the southern boundary of the map area (Fig. 44), Mississippian limestones and conglomerates make-up the valley walls for a distance of several kilometers before being replaced by Devonian conglomerates and shales.

Near its mouth Atigun Valley passes through a narrow band (2-3 km) of hard Mississippian limestone. Immediately north of the white limestone mountains the Atigun River turns abruptly northeast, following a probable fault (Atigun Gorge) until it joins the Sagavanirktok River. The south side of the gorge is composed of north dipping Permian and Mesozoic sandstones, siltstones and shales. These rocks are in turn overlain by Cretaceous sediments in the Foothills Province (see Toolik site description).

SOIL LANDFORM MAP

Mile 198.7 – Mile 202 TAPS Haul Road

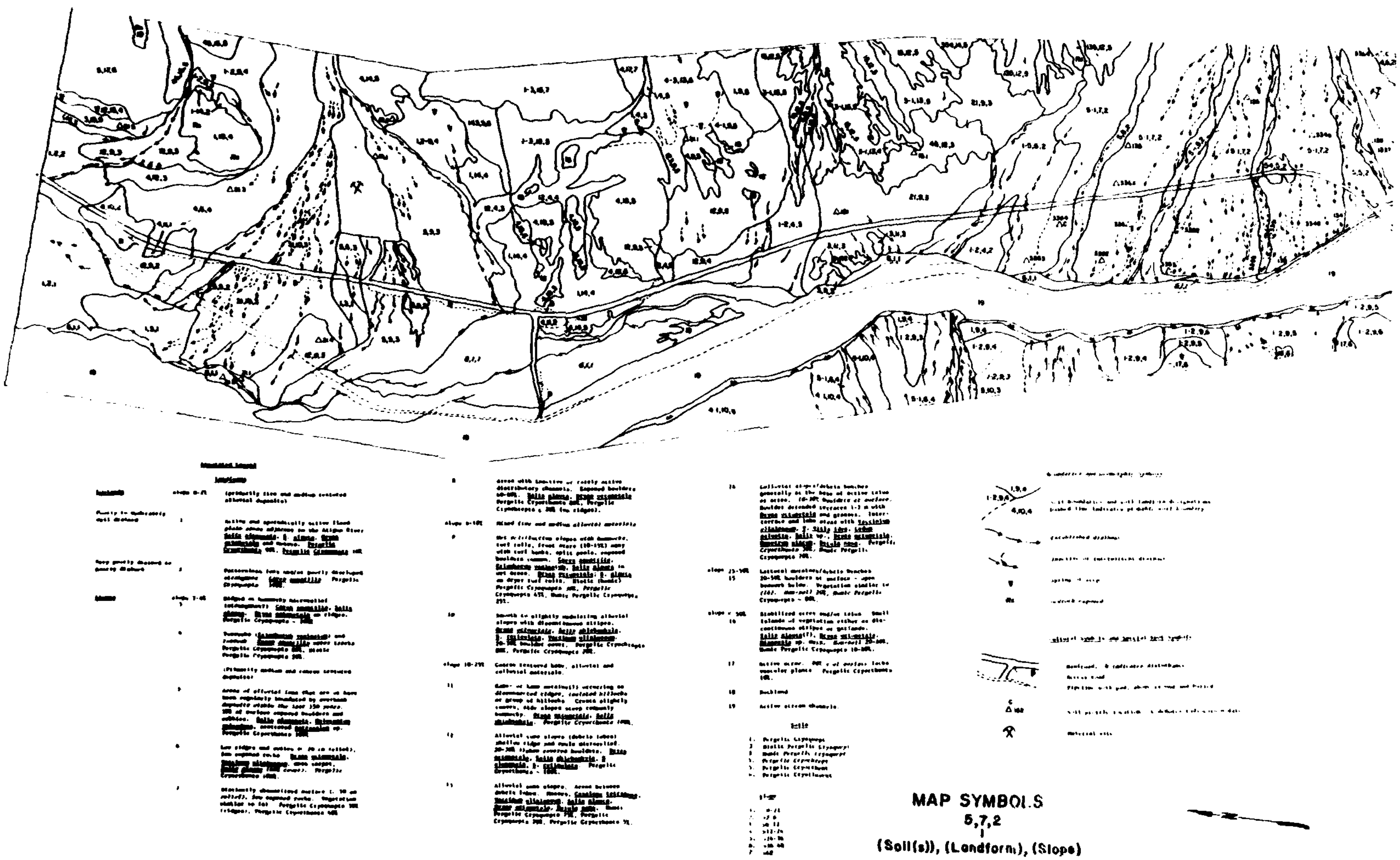


Fig. 44

A complex of alluvial fans, talus fans, colluvial/solifluction slopes, slump features and disconnected ice contact deposits comprise the lower slopes in the map area and the valley generally. The Atigun River flows, for the most part, on reworked alluvial fan materials and rounded outwash gravels some of which comprise a low discontinuous terrace adjacent to the river.

Topography

At about the position of Galbraith Lake summit elevations increase to near 1560 m from a general surface elevation of 780 m at the Toolik map site. Within less than 10 km of the lake elevations of the horn peaks reach to between 2190 and 2345 meters. Bottom elevations however, remain close to 875 m far up the valley. Throughout the map area the river flows between 940-1000 meters and to within 4.5 km of Atigun Pass (1500 m) river elevations remain close to 1125 m.

In cross profile Atigun Valley displays the classic U form of glaciated mountain valleys. In fact, small cirque glaciers can be found within a few kilometers of the valley at elevations generally between 1560 and 2030 m. The numerous horn peaks, deep, empty cirque basins (Fig.45) and their bounding arête or comb ridges attest to the once extensive glaciation of the region as a whole.

The upper valley walls of the canyon are characterized by narrow rockfall chutes many terminating in steep talus cones. Commonly the cones are separated by scree slopes below rock walls (Fig.46). Typically the scree shows areas temporarily stabilized by willows and mountains arvens (Dryas

Fig. 45. View into cirque at Continental Divide arête ridges such as that on skyline, terminate in horn peaks. Avalanche cones occur on headwall and neoglacial(?) moraines or protalus rampart, appears in the center.

Fig. 46. Scree slope (55%). Contributing rock outcrops above. Salix glauca(?) stripes and garlands have Dryas octopetala mats on downslope side. Soils beneath D. octopetala are tentatively classified as Histic Cryorthents.

octopetala. These are in the form of discontinuous slope-parallel stripes or in some cases garlands (see soils section). More deeply incised chutes with extensive source areas produce steep alluvial cones (alluvial talus). Some of these forms are .5 km or more across their toes (Fig.47). They are characterized by numerous active and formerly active mudflow channels and embankments. Much of the surface of these forms supports vegetation. There is a continium between talus cones and alluvial cones.

At the junction or overlap area between some of the alluvial cones are curved boulder ramparts (Fig.47). The valley face of these features is composed of angular boulders and rises abruptly to a height of 10 m or more from steep (30%) slopes. Behind the rampart is a platform or tread that slopes to 7% or less toward the valley wall. Commonly there is a depression in this surface, the site of a pond or former pond. In some cases the rampart has been breached with a V shaped trough leading to the depression. Slopes above the tread area are composed of talus cones and/or scree that terminate on the tread. The rampart features are most common on the west valley wall of the map area. They also occur on the east valley wall near the valley head where they terminate at river level. Although the origin and significance of the ramparts is not completely understood, their forms suggest slump failure of a thick talus cone possibly one terminating or supported by stagnant glacial ice. Fines have been removed from the boulder face of the rampart by entrainment and snowbank sapping. At least one of the larger forms displays a group of nested, curved protalus ramparts

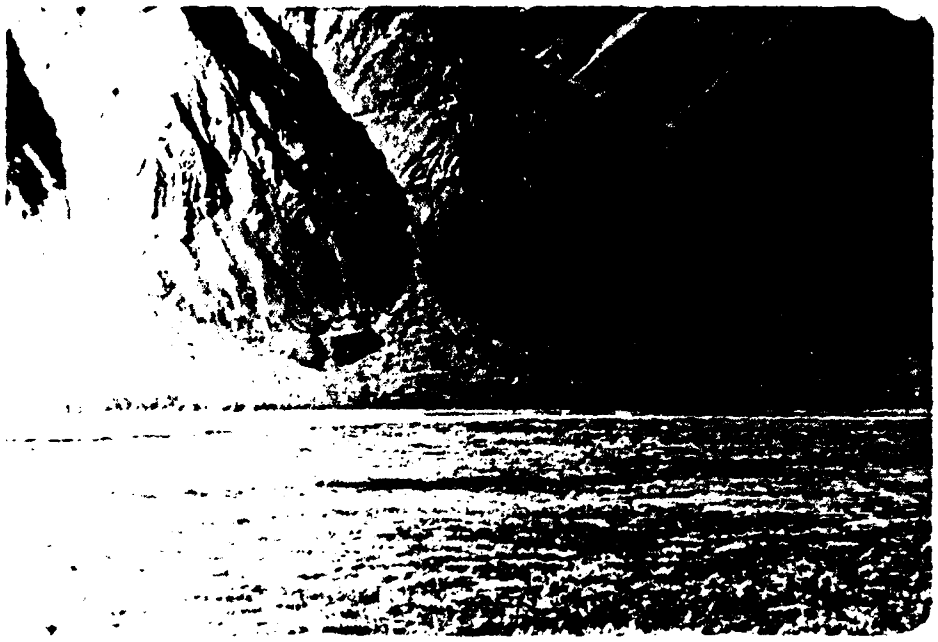


Fig. 47. A series of alluvial cones developed from shaley bedrock immediately south of the map area. These fans are steep (25%) and all have evidence of active debris flows. Note ramparts between cones at base of faceted spurs.

Fig. 48. Alluvial fan (slope 14%) displaying characteristics intermediate between the alluvial cone (far right) and the broad low angle (5%) fans eminating from extensive valley systems (Figs. 44 and 50.

developed on the tread. These have been formed from fragments, loosened by freeze-thaw, sliding over large snowbanks to the tread. The number of protalus ramparts suggests either a progressive thinning (recession) of the seasonal snowbank (climatic significance) or the seasonal variability in extent of the snowbank (no climatic significance).

Within the canyon and specifically within the map area are several large (2-3 km wide) low angle (4-6%) alluvial fans eminating from extensive tributary drainages (see Figs. 44 and 49). Such features have had a long history of shifting channel development. They are composed generally of finer materials than alluvial or talus cones. It should be pointed out that here again there is a range in forms intermediate between the alluvial cone and fan (Fig. 48).

All valley wall alluvial cones and fans post-date the last glacial advance through Atigun Valley (probably less than 12,000 yr. B.P.) (Hamilton and Porter, 1975). Glacial deposits, mostly kame and/or latteral moraines, are found sporadically on the valley walls (usually on the east side) where they have not been buried or removed by talus and alluvial materials. In some cases steep fronted (47%) latteral moraine terraces have undergone (or are undergoing) destruction by mudflow, the result of supersaturated moraine and colluvial material moving over permafrost (Fig. 53). Mudflow scars deepen by thermokarst and thermal erosion. One such flow and erosion was observed on 3 September 1979 approximately 6 km north of the map area. Within the map area itself only scattered small remnants of latteral moraine exist. At lower elevations on slopes and in some cases adjacent to

the river are remnants of kames composed of poorly stratified sands and gravels.

Between alluvial fans and cones, below scree or colluvial slopes or latteral moraines are wet solifluction slopes (15-20%) characterized by solifluction lobes, hummocks and swales, split pools and frost scars. Drier, coarser textured colluvial slopes commonly occur below talus or scree slopes.

Wet lowlands are not extensive in the map area. Those that do occur display poorly developed strangmoor or have forms transitional to solifluction slopes. In the northern portion of the canyon from Galbraith Lake south for about 7 km are extensive marshy lowlands (generally the site of one or more former more extensive lakes) with strangmoor and weakly developed low centered polygons. As the Atigun River enters the region it changes from a braided form to a meandering one.

At the confluence of the main or west branch of the Atigun River with the east branch (which contains the map site) is an extensive wet area characterized by a mixed assemblage of high and low centered polygons and thermokarst pools. This area is contained against alluvial slopes by higher elevation fine textured materials (possibly moraine) the surface of which is dominated by frost scars. The feature was formerly more extensive but has been cut by both the east and west branches of the river.

Permafrost

Active layer thickness, or more precisely depth to permanent ice, ranges widely in the map area. On dry,bouldery colluvial slopes, alluvial cones and fans, it probably extends to 2 m or more. The full thickness is seldom realized as the rocky character of the deposits limit hand excavation. On wetter finer textured colluvial and solifluction slopes, permafrost is generally encountered between 40 and 60 cm (occasionally as shallow as 20 cm) while in areas of strangmoor it is between 60 and 65 cm.

Vegetation

The juxtaposition of very different micro-sites produces in many parts of the map area a complex vegetation pattern. The *Dryas octopetala*, *Salix glauca* association on steep (55%) shale scree has already been noted (see Fig.46). Such slopes commonly terminate in lower angle colluvial foot slopes composed almost entirely of boxwork of boulders. Permanent vegetation here consists of a mat of *D. octopetala*, *Vaccinium uliginosum*, *S. glauca*, some *B. nana* (Fig.49). Where snowbanks occur *Cassiope tetragona* and *Empetrum* sp. become important. A similar plant association occurs on the dryer areas of alluvial fans and cones. On the lower, finer textured and more moist areas of alluvial fans, *B. nana* may comprise 50% or more of the shrub vegetation. Active parts of alluvial fans or cones are dominated by willow, especially *S. alaxensis*; thickets which may reach 2 m in height and 50-60 years in age. Beneath these tall shrubs there is commonly a carpet of moss, *Hylocomium splendens* with *Equisetum arvens* and *Astragalus* spp. *H. splendens* is also a significant component of the vegetation of small, infrequently used distributary channels.

Fig. 49. Stable talus slope below active scree. Note an open box work of boulders below vegetation mat. During meltoff such deposits transmit large volumes of water to lower solifluctions slopes (see Fig. 53). Histic Cryorthents commonly develop on stable parts of such slopes.

In addition to D. octopetala and V. ulginosum, Arctostaphylos sp., Salix phlibophylla, Salix reticulata, C. tetragona and grasses are common to the well-drained kames and/or gravel terraces.

Wet and moist solifluction slopes are characterized by sedges, especially Carex spp. including C. aquatilis and C. begelowii, Salix sp. and scattered Betula exilis with Tomenthypnum nitens, the dominant moss. Tussocks of Eriophorum vaginatum are common to solifluction slopes, especially in shallow drainage areas and, in a few cases on lower slope positions form areas of tundra similar to those further north. Carex aquatilis dominates in the strangmoor areas with Salix sp. and B. nana common to pronounced strangs or hummocks.

The above descriptions are not intended to be complete, but only to include some of the more conspicuous species and those associated with particular soil moisture or site stability conditions. A detailed vegetation map of part of the northern end of the soil landform map site was completed in 1976 (Webber et al., 1978).

Climate

The available climate data indicate that thaw season precipitation for the map area is somewhat greater than at the Toolik site (Haugen, 1980). This is in keeping with the general trend of increasing precipitation from coastal areas into the mountains (Haugen and Brown, 1980; Wendler et al., 1974). Total annual precipitation near the study site is probably between 130 and 175 a month with about 60% coming during the thaw season. Most of the thaw season precipitation falls as rain and much of this from convective or local orographic storms. Summer temperatures are somewhat similar to those at the Toolik site. Summer wind direction is predominately from the south and katabatic in origin. Table 3 summarizes two significant climatic variables for the areas north of the Continental Divide, see also page 23.

Table 3

Summary of thaw season precipitation and cumulative degree days from Atigun Canyon site north.

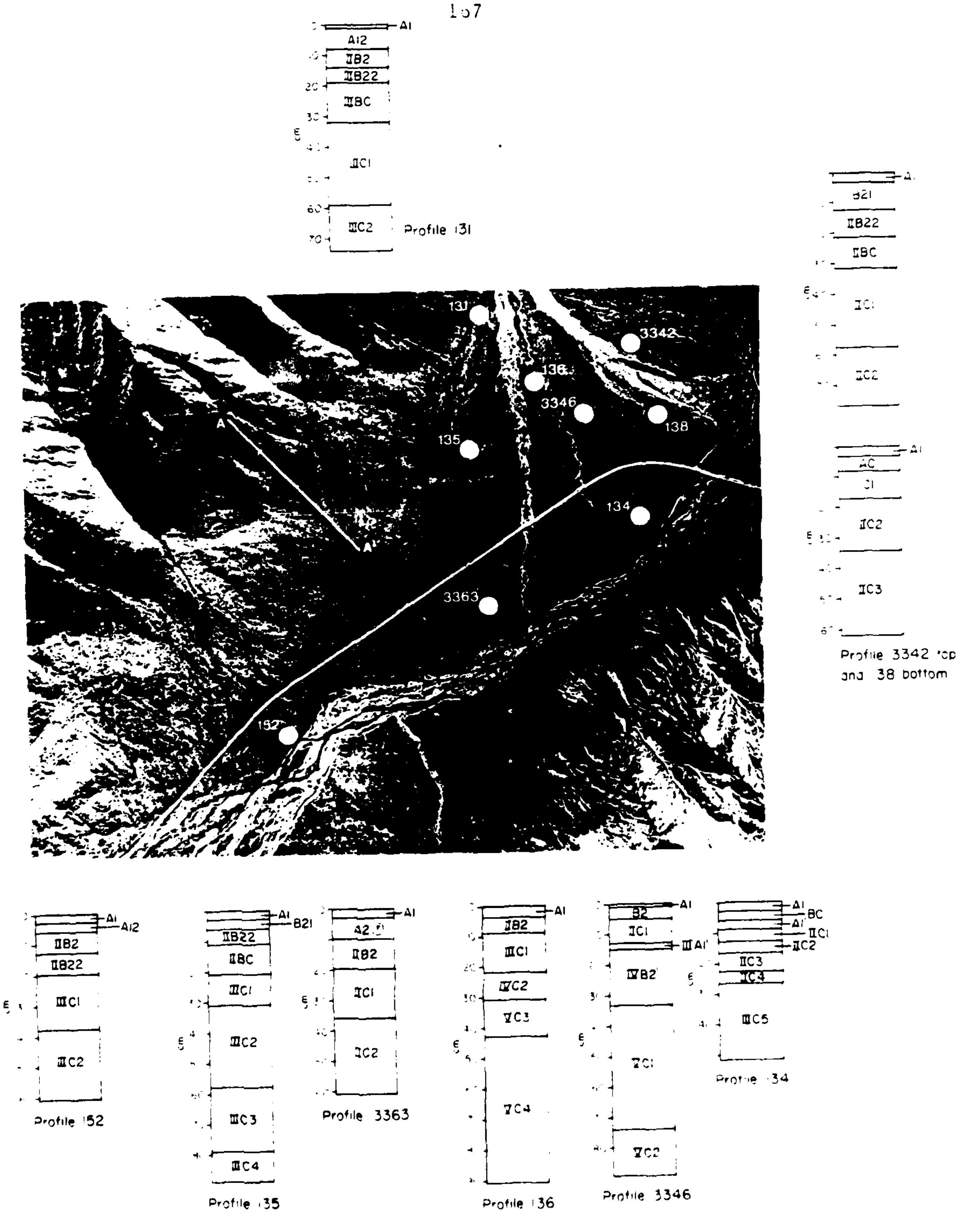
Site	That Season Precipitation (mm)		Thaw Degree Days
Prudhoe Bay W.G.	70(2)	Prudhoe Bay (ARCO)	7.4(4)
Sagwon(3) W.G.	87(4)	Happy Valley	1000(4)
Toolik W.G.	156(2)	Toolik River	1117(2)
Atigun Camp	163(4)		902(4)

Data compiled from Haugen (1980)
( ) number of years record
W.G. Wyoming gage

Soils

In geomorphically very dynamic regions such as mountains where land surfaces are continually being created and destroyed, little opportunity exists for the long term interactions among climate, vegetation and topography that alter parent materials and bring about the development of soil horizons. Even where well drained quasi-stable surfaces do exist the rates of chemical and biochemical reactions are much reduced in the cold, often dry soil climate. Thus it is not surprising that a high percentage of the soils of Atigun Valley belong within the order Entisols - those soils that display little or no evidence of the development of pedogenic horizons.

The microrelief of the surface of alluvial cones and fans is a non-regular assemblage of depressions, troughs, ridges and boulder levees of widely ranging stability and age. Thus the soils show a considerable range in morphology (Fig. 50) - most are classified as Pergelic Cryorthents - the cold, coarse textured Entisols (Soil Survey Staff, 1975).

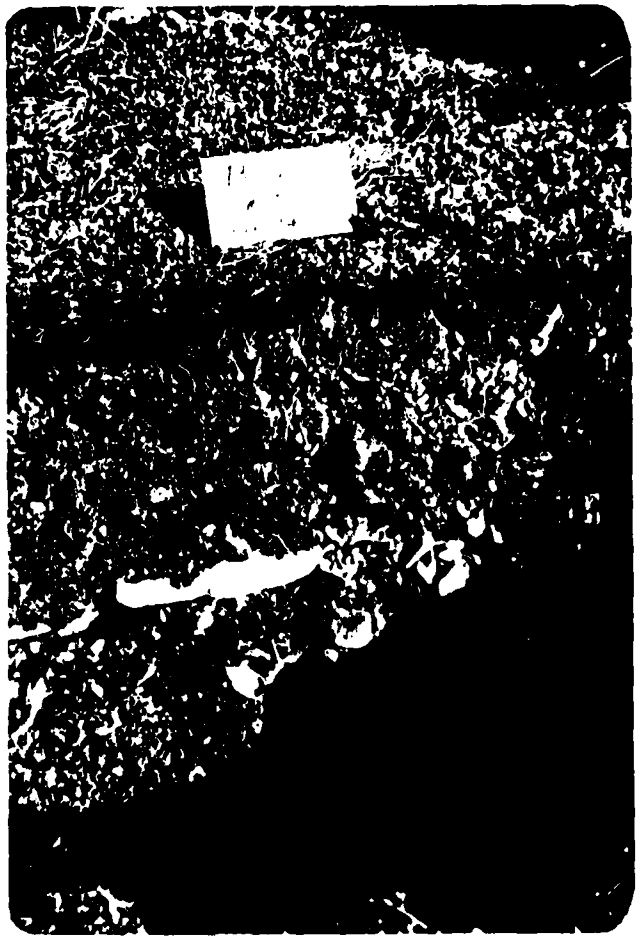

Profile 131
131
3342
136
3346
138
135
A
A'
134
3363
152
Profile 3342 top
and 138 bottom
Profile 152
Profile 135
Profile 3363
Profile 136
Profile 3346
Profile 134

50
51
52
53

Many alluvial cones, especially the steeper more active ones, have extensive areas of bouldery debris (debris fans, debris levees and channels). The deposits generally lack low matted vegetation, instead are discontinuous thickets of Salix alaxensis and S. glauca. Rocks have only a patchy cover of small lichens or lack them altogether. The soils which do occur are Cryorthents (Fig. 51a) some of which have a complex morphology with features indicating the movement of fines down within the profile as well as the release of iron and its reprecipitation (see profile 19.1). Such surfaces are generally < 450 years old and most are < 150 years old. In some of the channels (inactive) where conditions are more moist, mosses, lichens and some vascular plants occur, and although the soils are still Cryorthents, their upper horizons (a few to 10 cm) are finer textured (silt loams) and may contain appreciable organic matter.

Farther down slope on the alluvial cones and especially on the broad low angle fans the ridge and channel topography becomes subdued, particularly on the older inactive areas. The soils in such areas commonly display fine textured upper horizons (0-20 cm). The A1 horizon may have considerable organic matter and overlie a thin oxidized B2 horizon (color B horizon). Below the B horizon textures become sandy gravels or gravelly sands in which cobbles may constitute 70% or more of the volume. It is not uncommon to encounter thin discontinuous A1 horizons buried in these coarse materials. Silt coatings are common on the upper surface of mahy of the larger fragments. The fine textured surface horizons reflect the waining of depositional activity through

a



b

Fig.51a. Pergelic Cryorthent (profile 138, Fig.50) typical of young < 150 yr. surfaces of alluvial fans and cones. Profile has developed under Salix alaxensis and moss. Coarse skeleton > 60%.

b. Pergelic Cryochrept (Profile 3342). Profile displays an interrupted eluvial horizon marked by vales just below A1 horizon and strongly oxidized B horizon. Profile development probably represents 4500 years or more.

a decrease in transporting energy as the active debris channels moved away. Some proportion may also have been contributed by wind deposition.

Ages of the lower fan surfaces range widely. Lichenometric dating based upon Rhizocarpon geographicium suggests that a major part of the large fan in Figure 52 ranges in age from < 150 years in some channel areas to as much as 3400 years between some channels.* The range between 450 and 1500 years appears most common. A radiometric age of 495 ± 155 (GX 5114) was obtained from A1 horizon material buried between 28 and 34 cm (profile 3364) in an area with a lichen age between 450-1500 yrs.

The oldest part of the alluvial fan, Figure 52, is to the north of the main active channel and barrow pit. Lichen dates here indicate surface stability for between 2000 and 4500 years. Using the growth rate of 5.4 mm/100 years (Calkin and Ellis, 1980) for R. geographicium in Atigun Valley the surface stability may be only 1800-2200 years; conversely, had the Colorado Front Range growth curve been used (Webber and Andrews, 1973) an age closer to 6000 years would have been obtained. The antiquity of this surface is supported by a single radiocarbon date of 8485 ± 435 yr. B.P. (GX 5113) which was obtained on wood fragments at a depth of 158 cm. The soils of this surface show some of the strongest profile characterization of the Cryorthents (profile 3342, Fig. 50, Fig. 51b).

Among the oldest and most stable surfaces in the map area are kame or kame moraine terraces. Subsequent to ice retreat these features have

* Lichens, especially Rhizocarpon geographicium have been widely used and can provide rather precise dates where suitable control surfaces are available and climatic gradients are known (Webber and Andrews, 1973). Since both are lacking in the Atigun Valley area, lichen growth rates cannot be known with precision. Maximum lichen diameter was employed and referenced to the Baffin Island curve of Miller and Andrews (1972). The technique does provide a relative time frame in the absence of suitable radiocarbon dates.

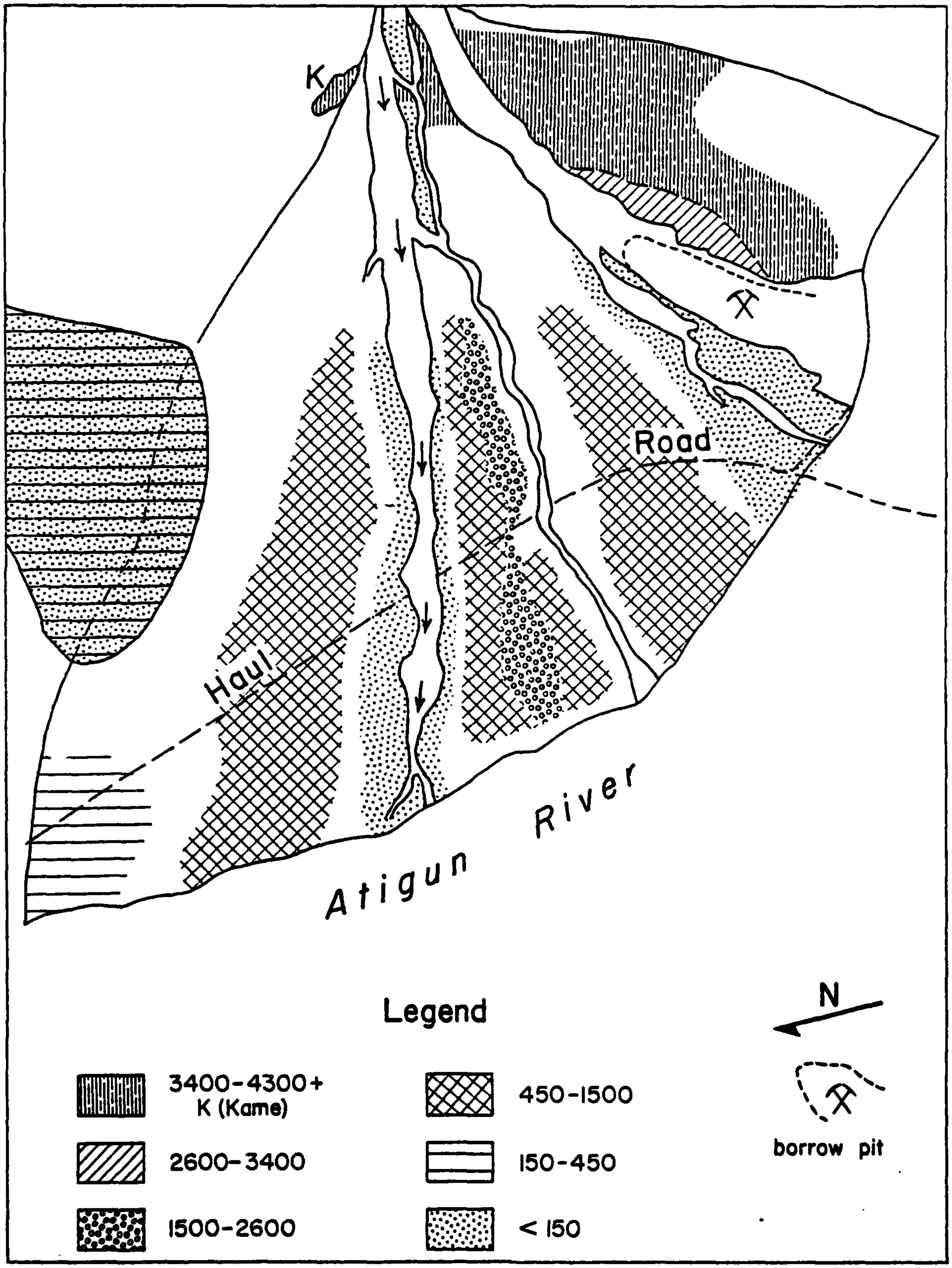


Fig. 52. Surface ages of alluvial fan derived by lichenometrid dating. Fan and soil profiles shown in Fig. 50.

for the most part been buried or engulfed by alluvial deposits. It is within the kame deposits that significant soil profile development has taken place (profile 152 and 13.1, Fig. 50). Both soils are classified as Pergelic Cryorthents, being excluded from the Inceptisols by virtue of the coarse texture of their fine earth fractions. Both soils and profile 3242 would be considered as Arctic Brown soils (Tedrow and Hill, 1955 and Drew and Tedrow, 1957). A few of the orthents developed in old, stable drainageways on alluvial surfaces are wet and mottled and belong to an aquic subgroup (Aquic "Pergelic" Cryorthents).

The very steep scree slopes and avalanche cones are generally devoid of soil however, the stabilized debris islands commonly have thick accumulations of decomposed organic matter that acts as a matrix surrounding gravel fragments and boulders. These materials lie on unaltered scree (profile 15.2, Figs. 46 and 53). Classification of such soils is uncertain since they do not meet some of the criteria for the Folist subgroup as they are now defined. They may be Histic Cryorthents (Entisols) however, no Histic subgroup is currently recognized. Alternatively they may be Cryofolists (Histosols). Similar soils may be encountered on colluvial deposits down slope from scree slopes from which the fines have been removed on the distal side. These organic materials surround rock fragments above an open box work (Fig. 49).

Wet, fine textured soils are common down slope from alluvial fans and cones. The finer materials are derived from upslope by surface wash and snow bank sapping or by the process of piping and surface

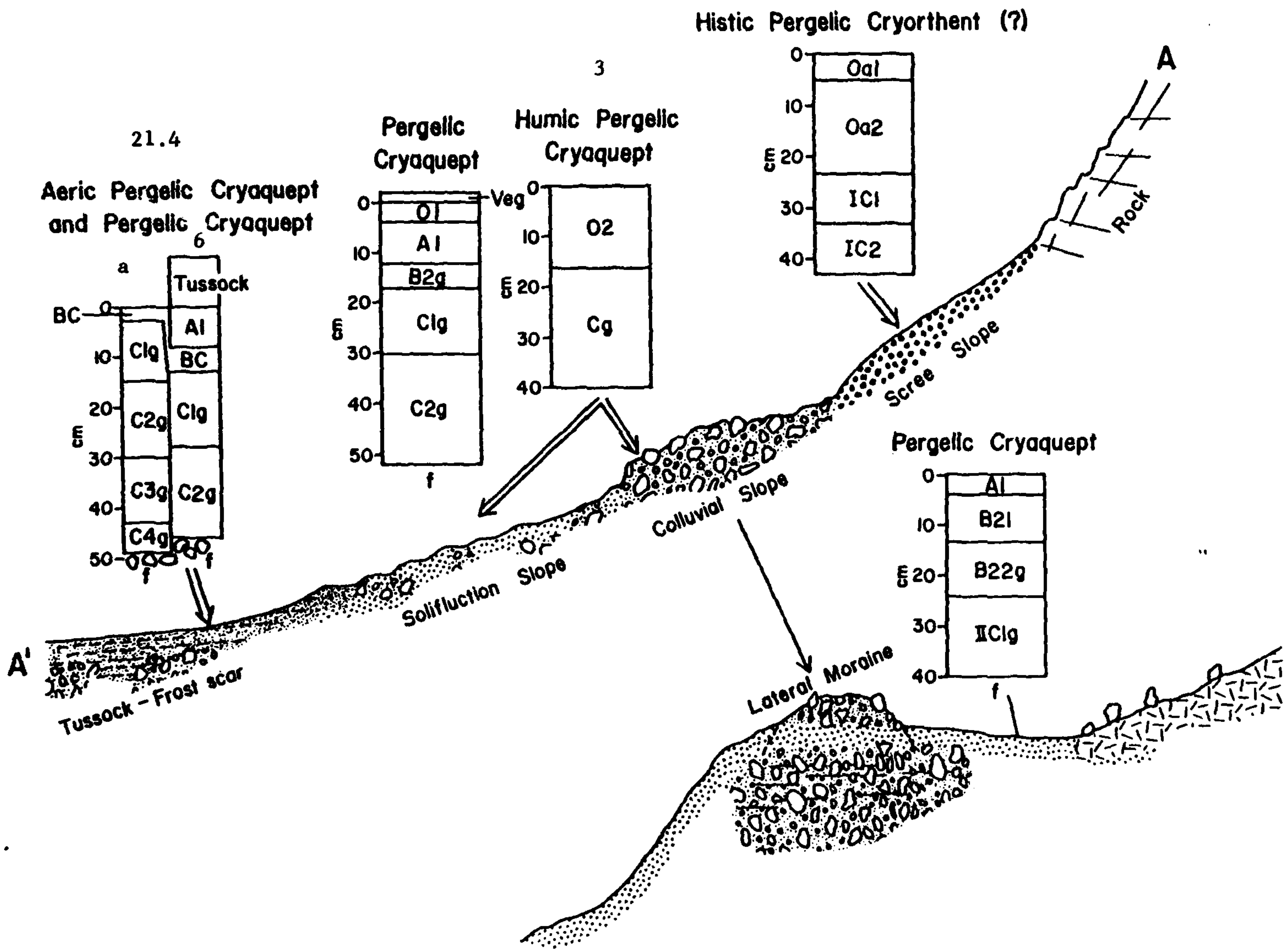


Fig. 53. Schematic section showing soil profiles and their landform associations along profile A-A' Fig. 50.

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SOIL-LANDSCAPE RELATIONS AT SELECTED SITES ALONG ENVIRONMENTAL --ETC(U)
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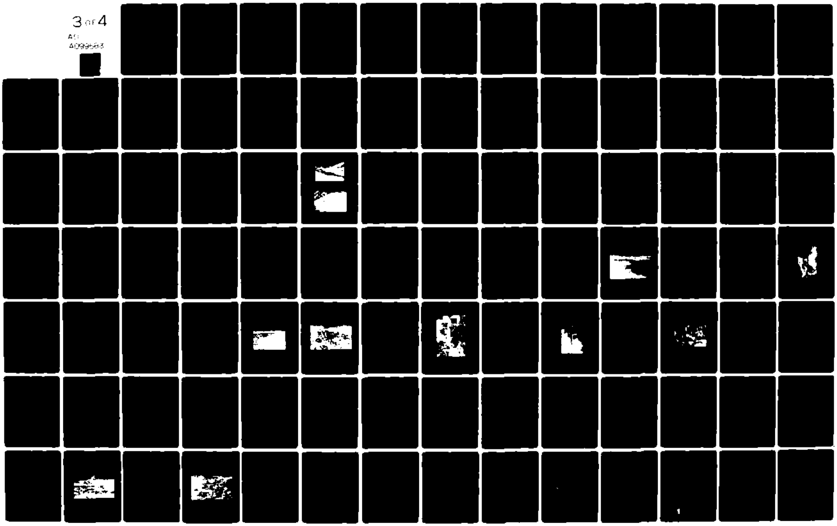
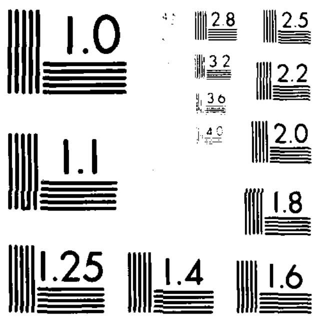




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

redistribution. The latter process is important on slopes below steep alluvial cones. Considerable meltwater and runoff is conducted below the surface of the cones in the coarse open box work structure of the debris and reappears at or downslope from the toe of the cone. The high water content, and fine texture of the soils coupled with shallow ice rich permafrost results in solifluction and a rough complex microtopography (Fig. 53). For the most part soils of the slopes belong to the order Inceptisols and because of their moisture regime to the suborder Aquepts (see profiles 21.4 a and b, Fig. 53).

Because of the instability of these slopes most profiles have organic matter enmixed with wet, mottled C horizon materials. Humic Pergelic Cryaquepts are common to the more elevated mounds and crests of solifluction lobes (profile 3, Fig. 53) while lighter colored Aeric Pergelic Cryaquepts may be described from some better drained areas, e.g., some frost scars. Locally in such soils a strongly developed granular to subangular blocky structure may develop to depths of 30 cm or more. The structure is not pedogenic but rather the product of repeated ice segregation in the clay rich mineral soil.

Tussocks and frost scars are common to the lower parts of some solifluction slopes, especially near drainages. Soils are Pergelic Cryaquepts and occasionally Aeric Pergelic Cryaquepts similar to those of the tussock tundra further to the north in the Foothills region.

Wet sedge meadows are not common in the map area and those that do occur are of small size. Farther north in the valley, sedge meadows together with Pergelic and Histic Pergelic Cryaquept soils are an important feature of the landscape. In the map area the fibrous sedge

peat is not sufficiently thick to permit the term Histic to be used. Mineral materials are grey, unmottled and sandy textured. Low elevation, narrow and discontinuous alluvial terraces occur on the east side of the Atigun River. Scour channels are common on the terraces and most are flooded for short periods in most years. The coarse textured soils thaw deeply and morphologically there is little difference from those of the alluvial fans and are thus classified as Cryorthents.

Landscape Evolution

The Atigun site occurs very near the source areas of the Pleistocene glaciers that repeatedly sculptured the region. The map site was overridden by ice of all glacial advances except the most recent or neoglacial event that occurred sometime after about 6000 yr. B.P.

Although the sequence of glacial events has been established generally for the region (Hamilton and Porter, 1975) relatively little is known of their precise timing. Stagnating ice of the Itkillik II glacier that built moraines near the mouth of the valley some 12,000 yr. B.P. may have been, in part, coextensive with an ice readvance several thousand years later (Hamilton and Porter, 1975). Deposits of a still later advance, the Alapak Mountain glaciation are known from other major north trending valleys. They probably occur also in the Atigun Valley at the map site area although they have not been identified. It is possible that the Atigun Valley contained active and/or stagnant ice up through the disappearance of the Alapak Mountain ice.

The radiocarbon date of ~ 8500 yr. B.P. from the large alluvial fan at the south end of the map site (Fig.50) supports the idea that the

Atigun Valley and similar valleys were free of Itkillik ice by or near the beginning of Holocene time (Hamilton and Porter, 1975). At present, meltwater is supplied to this fan from a small cirque glacier some 2.5 km from its apex. The glacier (at 1375 m) probably advanced into the Atigun Valley during the Alapak glacial event, and certainly before it, and removed most if not all alluvial deposits. Very possibly some of the water washed (kame) deposits near the head of the fan as well as those near the Atigun River may be products of the last ice advance. Lateral and kame moraine deposits higher on the valley walls date to earlier phases of Itkillik glaciation.

The present form of the alluvial cones and fans was probably developed quickly upon final melting of the valley ice. In all cases, the large alluvial fans were developed rapidly from outwash as the tributary glaciers retreated to their cirque basins. The Atigun River has removed the distal or toe end of many of the large fans.

Kame surfaces and certain areas of the large alluvial fans appear to have remained stable for periods of 3500 to 6000 years. Most other surfaces in the valley are very much younger.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soil/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount ($<$ 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophospate extraction
VC	Very coarse sand 1-2 mm; C coarse sand 1-0.5 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class:	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, clay loam; sicl, silty clay loam.

Atigun Canyon
Selected Edaphic Characteristics

Soil[5] Profile	Depth (cm)	Horizon	Color[4]	% Organic carbon	Exchangeable Cations Meq/100g Ca	Mg	K	Fe(%) CD	Fe(%) OX	Fe(%) SP	Al(%) CD	Al(%) OX	Al(%) SP	pH	Particle Size sands mm(%) VC	C	M	F	VF	TOT	silt/clay μm(%) C	F	C	F	Text Class
152	0-1	A1	10YR2/2											5.4[2]											
	1-8	A12	10YR4/3	7.2										4.7											
	8-14	B21	10YR3/2		0.9	0.7	0.23	1.89	0.27	0.60	0.25	0.20	0.39	4.7	58	11	2	2	1	73	3	13	8	2	csl
	14-19	B22	10YR4/4		1.0	0.7	0.13	1.46	0.16	0.25	0.24	0.17	0.24	5.2	63	16	2	1	T	82	0	12	10	2	csl
	19-32	BC	2.5Y5/2		1.3	1.0	0.11	1.43 0.24[3]	0.18 0.77	0.19 0.54	0.24 0.18	0.24 0.27	0.19 0.45	5.2	51	17	4	3	1	75	1	12	11	1	csl
	32-57	C1	2.5Y5/2					0.53	0.34	0.06	0.06	0.16	0.16	6.4	50	20	4	3	1	78	0	13	10	T	csl
	57-74	IIC2	5Y4/2					0.39	0.46	0.02	0.05	0.12	0.42	$CaCO_3$	56	25	3	2	T	86	0	7	8	T	lcs
13.1	0-4	O1/A1	5YR2/2-10YR3/3	6.0	3.0	1.9	0.34	2.3			0.42			4.7[2]	6	6	3	6	9	30	22	28	17	3	sil
	4-10	B21	10YR4/4	2.3	1.0	0.6	0.21	2.2			0.41			4.9	10	9	4	9	10	41	14	27	15	2	l
	10-18	B22	10YR3/3	0.9	0.5	0.3	0.07	1.0			0.21			5.1	14	13	6	12	10	55	12	25	6	2	sl
	18-36	C1	10YR4/3	0.6	1.6	1.2	0.07	1.1			0.12			5.5	16	15	7	13	8	60	10	24	7	T	sl
	36-58	C2	10YR4/4	0.3	3.5	1.8	0.08	1.3			0.10			6.4	21	17	7	12	7	64	6	17	11	2	scl
3342	0-3	A1	5YR3/3	10.53										4.5[1]											
	3-12	B21	7.5YR4/6	2.31				2.48	0.36	0.55	0.37	0.30	0.30	4.6	30	17	4	3	4	57	8	18	14	2	csl
	12-21	B22	7.5YR3/4					1.04	0.12	0.16	0.21	0.22	0.13	5.4	59	27	6	3	T	96	T	2	2	T	cs
	21-31	BC	7.5YR3/2					0.83	0.09	0.17	0.23	0.18	0.20	5.4	50	31	8	4	1	93	1	2	3	T	cs
	31-57	C1	2.5Y4/2											5.9	57	23	6	6	2	94	0	3	3	0	cs
	57-76	C2	2.5Y4/2					0.22	0.21	0.11	0.07	0.11	0.16	5.8	57	26	4	2	1	90	3	3	4	0	cs
138	0-3	A1	5YR3/2	20.2										5.4[1]											
	3-8	AC	2.5Y3/2					0.51	0.09	0.02	0.10	0.05	0.04	6.0	17	14	10	26	15	82	9	6	3	1	ls
	8-17	C1	2.5Y4/2					0.58	0.18	0.01	0.06	0.07	0.03	6.1	4	7	6	24	24	66	17	12	4	1	csl
	17-34	IIC2	10YR4/2					0.04	0.16	0.22	0.38	0.16	0.95	6.5	50	13	4	6	4	77	6	12	5	1	lcs
	34-62	IIC3	10YR4/2					0.04	0.18	0.25	0.35	0.19	0.85	6.8	52	27	6	4	1	89	T	7	4	1	cs
135	0-3	A1	10YR2/1	19.0				1.28	0.90	0.52	0.29	0.26	0.22	5.3[1]											
	3-6	B21	10YR3/4	6.1	4.3	2.1	0.24	1.89	1.07	0.91	0.39	0.24	0.29	4.7	9	8	4	9	6	36	13	34	14	3	l
	6-11	IIB22	10YR3/2		1.9	2.1	0.13	0.85	0.39	0.15	0.23	0.14	0.10	4.8	10	10	10	31	15	76	9	10	3	1	ls
	11-21	IIIBC	10YR3/2											5.0	37	23	9	11	4	84	3	8	5	1	lcs
	21-31	IIIC1	2.5Y3/2					0.82		0.056	0.06	0.04	0.02	6.0	38	25	8	9	3	85	2	8	4	1	lcs
	31-58	IVC2	5Y3/2					0.76	0.19	0.047	0.05	0.21	0.12	6.6	34	19	8	12	5	79	3	12	6	2	lcs
	58-79	IVC3	5Y4/2					0.50	0.14	0.028	0.04	0.16	0.08	6.2	50	26	6	5	2	88	1	6	3	1	cs
	79-89	VC4	5Y3/2					0.50	0.24	0.045	0.05	0.10	0.09	5.9											
3363	0-3	A1	10YR3/3	19.4				1.07	0.64	0.32	0.20	0.18	0.12	4.6[1]											
	3-10	A2	10YR5/4					0.78	0.25	0.07	0.14	0.07	0.08	4.4	7	5	10	30	13	71	13	9	6	1	fsl
	10-20	IIB2	10YR4/3					0.50	0.08	0.01	0.08	0.05	0.04		42	20	6	8	4	79	5	10	6	T	fsl
	20-36	IIIBC	2.5Y4/2											6.3	63	24	4	2	T	95	T	3	2	T	cs
	36-61	IIIC1	5Y4/2											6.4	61	23	5	3	1	94	T	4	2	T	cs
134	0-2	A1	10YR3/2	7.7										5.9[1]	T	T	T	1	5	7	25	46	17	5	sil
	2-9	B2	10YR3/2	4.0										6.0	5	10	8	21	16	60	14	14	8	4	fsl
	9-13	IIC1	5Y3/2											6.0	4	4	3	15	17	43	18	31	7	1	l
	13-23	IIIC2	2.5Y4/2					0.05	0.27	0.04	0.07	0.12	0.10	6.0	6	4	4	20	18	52	18	23	7	T	l
	23-27	IVC3	5Y3/2					0.06	0.25	0.04	0.06	0.12	0.12	6.4	6	13	13	34	13	78	7	8	7	T	ls
	27-38	VC4	5Y4/2											6.2	42	23	6	9	4	84	2	9	5	T	lcs
	38-52+	VC5	5Y4/2					0.04	0.21	0.03	0.06	0.10	0.09	6.6	37	29	9	6	3	83	4	7	5	1	lcs

Appendix B

Selected profile discriptions of the soils of the Atigun Canyon area. Refer to Figs. 43,50,53 and Appendix A for topographic setting and edaphic characteristics.

Site:	Atigun Canyon #15.2
	Steep scree slope. Salix garlands.
	Profile immediately downslope of garland.
Slope:	55%
Vegetation:	Dryas sp. moss
Classification:	Pergelic Cryofolist(?)
Depth/Horizon (cm)	
0-5 O1	Black (10YR 2/1) fine fibrous sapric organic matter; friable; structureless; acts as matrix in gravel; roots common. Abrupt, ruptic boundary.
5-23 Oa	Black (10YR 2/1) sapric organic; friable; acts as matrix; very weak fine subangular blocky to granular structure; fine shale gravel (50-60%); fragments have organic stain; fine roots common. Abrupt, wavy boundary.
23-33 C1	Dark brown (10YR 4/3) fine shale gravel ($<$ 1-1.5 cm); few fragments to 6 cm; fines (silty-clay loam); mostly as coatings and binding coarse sand fragments; lower surface of large rock fragments have nearly continuous iron coats; few fragments with carbonate coats. Gradual boundary.
33-43 C2	Dark greyish brown (10YR 4/2) fine and medium shale gravel; few fines (mostly discontinuous clay coatings); fragment size increases with depth; lower surfaces have patchy iron coats. Profile terminated.

Site:	Atigun Canyon #21.5 Boulder covered; colluvial slope at base of latteral moraine.
Slope:	36%
Vegetation:	Dryas sp. and scattered Salix sp.; Cassiope tetragona
Classification:	Humic Pergelic Cryaquept (provisional)
Depth/Horizon (cm)	
0-10 01	Very dark brown (10YR 2/1) fibric organic; mostly moss. Abrupt, smooth boundary.
10-17 A1	Black (10YR 2/1) organic silt loam; very fine fibrous; breaks down almost completely; roots common. Abrupt, smooth boundary.
17-35 A12	Black (10YR 2/1) organic silt loam; very slightly brittle; breaks to weak, medium angular blocky units; fine roots abundant. Profile terminated because of boulders.

Site:	Atigun Canyon HR113 1-76
	High level alluvial terrace
Slope:	2%
Vegetation:	_Dryas octopetala_; _Salix phlebaphylla_, mosses, lichens and _Arctostaphylos alpina_ in depressions
Classification:	Pergelic Cryorthent
Depth/Horizons (cm)	
0-3 O1	Dark reddish brown (5YR 2/2) highly organic silt loam (upper 0.6 cm) black (10YR 2/1) matrix of fine roots and stems. Abrupt, wavy boundary.
3-4 A1	Dark brown (10YR 3/3) loam; friable; fine granular structure; roots common. Abrupt, wavy boundary.
4-10 B21	Dark yellowish brown (10YR 4/4) loam; friable; > 25% gravel fragments; sporadic silt coats on top and on bottom of fragments with moderate, medium fine granular structure; roots common. Abrupt, wavy boundary.
10-18 B22	Dark brown (10YR 3/3) sandy loam; friable; ~ 60% of material coarser than 2 mm ~ 20% > 2.5 cm; gravel fragments have silt coats on upper surface with weak fine granular structure; lower side of fragments clear; few roots; Abrupt wavy boundary.
18-36 C1	Brown (10YR 4/3) sandy loam matrix; approximately 60% subrounded rock fragments to ~ 0.6 cm; larger rock fragments > 20%; bottom of fragments clear; few roots. Clear, wavy boundary.

Depth/Horizon (cm)	
36-58 C2	Dark yellowish brown (10YR 4/4) silty clay loam matrix binding granules and coating larger fragments; displays flow structure; coarse fragments 75-80% by volume. Profile terminated.

Site:	Atigun Pass HRL-76A.1
	West side of canyon. Long homogenous slope with fine reticulate pattern becoming somewhat drawn-out down slope. Shale gravel parent material. Sporadic frost scars, generally active in slope position.
Slope:	4^{o}
Vegetation:	Arctostaphylos alpina; Ledum palustre; Empetrum sp.; Salix alaxensis; Betula exilis Vaccinium uliginosum
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-5 A1	Dark reddish brown (5YR 2/2), dark reddish brown (5YR 3/2) smeared) organic-rich silt loam; friable; fine granular structure; roots common; abrupt, smooth boundary.
5-10 A12	Very dark brown (10YR 2/2) very dark brown (10YR 3/2 smeared) gravelly silt loam; friable; weak fine granular structure; gravel fragments .5 to 1 cm with silt coats on upper surface; larger non-shale fragments have $CaCO_3$ coats on underside; roots abundant. Abrupt, smooth boundary.
10-18 B2	Very dark grey (10YR 3/1) very dark grey brown (10YR 3/2 smeared) fine and medium shale gravel, loose; silt loam filling most interstices and coating fragments; many roots. Abrupt, smooth boundary.

Depth/Horizon (cm)	
18-38 C1	Dark grey (10YR 4/1) very dark grey (10YR 3/1 smeared) fine and medium shale gravel; silt loam coats on upper surface; thin sporadic iron coats on bottom. Abrupt, smooth boundary.
38-51 C2	Very dark grey (10YR 3/1) very dark grey (10YR 3/1 smeared) fine densely packed shale gravel; silt coats on top of fragments; no coatings on underside; roots few-absent. Profile terminated 27 August 1976.

Site:	Atigun Canyon HR1-19.1-76
	Alluvial fan. Rocks and boulders common on surface
Slope:	17%
Vegetation:	*Salix alaxensis*; *Salix glauca*; *Oxytropis* sp.; grasses; mosses; occasional *Betula exilis*.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
1-0	Living vegetation
0-4 A1	Very dark brown (10YR 2/2) organic fine sand; friable; fine gravel fragments common; few boulders; roots common. Abrupt, wavy to interrupted boundary.
4-11 BC	Grey (10YR 5/1) fine sand; loose; gravel fragments 60-70%; few organic fragments; roots common. Abrupt, wavy boundary.
11-23 ABb	Greyish brown (10YR 5/2) fine sandy loam; friable; weak fine granular structure; moderately decomposed organic fragments common; coarse fragments > 20%. Abrupt, wavy boundary.
23-32 B2b	Dark greyish brown (10YR 4/2) gravelly fine sand; loose; coarse fragments 25-30%; silt coatings on upper surface of fragments; fine roots common.
32-47 B22b	Greyish brown (10YR 5/2) gravelly medium and fine sand; loose; coarse fragments 40%; some weakly indurated areas (matrix) around fragments. Silt coats on tops of fragments; sporadic iron coatings on lower side of

Depth/Horizon (cm)	
	of fragments; carbonate coats on underside of larger fragments (8 cm +); fine roots plentiful; coarse roots common. Abrupt, wavy boundary.
47-84 C1	Dark greyish brown (10YR 4/2) sandy fine gravel (> 2.5 cm); matrix loose in skeleton (> 50%); some organic materials associated with larger fragments; carbonates on underside; loose, fine sand on upper surfaces; roots common. Abrupt, wavy to ruptic boundary.
84-109 C2	Dark greyish brown (10YR 4/2) fine to medium gravel (1-5 cm) and occasional boulders to 15 cm; loose but compact; carbonates sporadic on lower surface of gravel fragments; loamy fine sand on top and as matrix; few roots. Profile terminated.

Site:	Atigun Canyon HR1 5111-134
	Alluvial fan.
Slope:	6%
Vegetation:	Salix reticulata; Dryas octopetala; Salix sp.; moss lichen mat.
Classification:	Pergelic Cryorthent
Remarks:	Some horizons have been combined(*) for analyses, therefore correspondence to profile 134 Appendix A may not be exact.

Depth/Horizon (cm)	
2-0	Live vegetation
0-2 A1	Very dark greyish brown (10YR 3/2) organic silt loam; loose; weak very fine granular structure; moist; roots common. Abrupt, smooth boundary.
2-6* B2	Very dark greyish brown (2.5Y 3/2) silt loam; moist; loose; moderate fine granular structure. Abrupt, smooth boundary.
6-9* A1b	Very dark grey (10YR 3/2) organic fine sandy loam; moist; loose; weak very fine granular; many fine root fragments; roots common. Abrupt, wavy boundary.
9-13) IIC1	Dark olive grey (5Y 3/2) loam; moist; loose; single grain; few roots. Abrupt, wavy boundary.
13-17* IIC2	Olive grey (2.5Y 4/2) moist; loose; single grain; few fine and medium root fragments. Abrupt, wavy boundary.

Depth/Horizon (cm)	
17-23* IIIC3	Olive grey (2.5Y 4/2) gravelly loam; moist; loose; single grain; coarse fragments > 70%; few roots. Abrupt, wavy boundary.
23-27 IVC4	Dark olive grey (5Y 3/2) loamy sand; single grain; coarse fragments < 20%; few fine root fragments. Abrupt, wavy boundary.
27-38 VC5	Olive grey (5Y 4/2) gravelly loamy coarse sand; coarse fragments > 70%; fine sandy loam coats on fragment tops; stone layer at base of horizon. Abrupt, wavy boundary.
38-52* VC6	Olive grey (5Y 4/2) gravelly loamy coarse sand; wet; fine sandy loam coats on tops of larger fragments; few roots. Profile terminated.

Site:	Atigun Canyon HR1-5111-135
	Alluvial fan.
Slope:	6%
Vegetation:	<u>Betula exilis</u>; <u>Ledum palustre</u>; patches of <u>Dryas octopetala</u>; moss/lichen mat. Scattered <u>Salix</u> sp.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
3-0	Live vegetation
0-3 A1	Black (10YR 2/2) organic loam; friable; breaks to weak fine granular structure; roots common. Abrupt, wavy boundary.
3-6 B21	Dark yellowish brown (10YR 3/4) loamy sand; weak fine granular structure; moist; loose; coarse fragments < 10%; no mottles; roots common. Abrupt, wavy boundary.
6-11 B22	Very dark greyish brown (10YR 3/2) loamy sand; moist; loose; few roots. Abrupt wavy boundary.
11-21 BC	Very dark greyish brown (10YR 3/2) loamy coarse sand; loose; moist; coarse fragments > 50%; cobbles have silt coats on top; iron stains on underside. Clear, wavy boundary.
21-31 C1	Very dark greyish brown (2.5Y 3/2) loamy sand; coarse fragments > 70%; cobbles have silt coats on top; iron stains on underside; sporadic carbonate deposits. Abrupt, wavy boundary.

Depth/Horizon (cm)	
31-58 C2	Dark olive grey (5Y 3/2) loamy coarse sand; coarse fragments > 80%; silt coats on top; iron stains on underside with sporadic carbonates; few roots. Clear, wavy boundary.
58-79 IIC3	Olive grey (5Y 4/2) coarse sand; loose; coarse fragments > 70%; moist; silt coats on top; iron stains on lower side. Gradual boundary.
79-89	Olive grey (5Y 3/2) coarse sand; loose; gravel and cobbles > 80%; silt coats on tops. Profile terminated.

Site: Atigun Canyon HR1 5111-138

Alluvial fan. Exposed stones < 10%

Slope: ≤ 6%

Vegetation: *Salix alaxensis*; *Pyrola* sp.; many dead *S. alaxsensis*; moss (*Hylocomium* sp.) carpet with lichens.

Classification: Pergelic Cryorthent

Depth/Horizon (cm)	
5-0	Live vegetation
0-3 A1	Dark olive grey (5YR 3/2) organic loamy sand; moist; friable; roots abundant. Abrupt, wavy boundary.
3-8 AC	Very dark greyish brown (2.5Y 3/2) coarse sandy loam; fine gravel fragments 30%; structureless; moist; friable; roots abundant. Abrupt, ruptic boundary.
8-17 C1	Dark greyish brown (2.5Y 4/2) loamy coarse sand; moist; friable; weak, medium angular blocky structure; cobbles and stones 60%; roots abundant; very dark greyish brown (10YR 3/2) silt coats on rock tops. Clear, wavy boundary.
17-34 IIC2	Dark grey (10YR 4/2) fine gravely loamy coarse sand; loose; moist; fine earth fills interstices of cobbles and stones; fine fragments mostly platy with silt coats on top; roots common to few with depth. Clear, wavy boundary.

Depth/Horizon (cm)	
34-62 IIC3	Dark greyish brown (10YR 4/2) gravelly coarse sand; moist, loose; thin brown (10YR 5/3) silt coats on tops; bottoms clean and dry. Tops moist and wet. Profile terminated.

Site:	Atigun Canyon HR1-5111-152
	Ice contact deposit; possible kame moraine
Slope	2%
Vegetation:	_Dryas octopetala_; _Salix phlebophylla_; scattered grasses; moss/lichen mat.
Classification	Pergelic Cryorthent
Depth/Horizon (cm)	
0-1 A1	Brown (10YR 2/2) organic loamy fine sand; friable; structureless; moist; roots common. Abrupt, smooth boundary.
1-8 A12	Brown (10YR 4/3) loamy fine sand; friable; structureless; moist; roots common. Abrupt, wavy boundary.
8-14 B22	Dark brown (10YR 3/2) coarse sandy loam; coarse fragments; have continuous iron coats on bottoms; abundant roots. Abrupt, wavy boundary.
14-19 B23	Dark yellowish brown (10YR 4/4) coarse sandy loam; fine gravel matrix; abundant roots; continuous iron stains on bottom of larger fragments. Clear, wavy boundary.
19-22 BC	Greyish brown (2.5Y 5/2) coarse sandy loam; medium gravel matrix; continuous silt coats on gravel tops; continuous iron stains on bottoms. Clear, wavy boundary.
32-57 C1	Greyish brown (2.5Y 5/2) coarse sandy loam; compact medium gravel with few cobbles; silt coats have fine gravel and very coarse sand adhering; sporadic carbonates on some larger rocks and cementation of fine particles on lower side; few roots. Clear, wavy boundary.

Depth/Horizon (cm)	
57-74 C2	Dark grey (5Y 4/2) loamy coarse sand (5Y 5/3) olive silt coats; iron stains; HCl reaction; roots few to absent. Profile terminated.

Site:	Atigun Canyon #3363
	Alluvial fan, many large rocks at surface.
Slope:	2%
Vegetation:	Betula exilis; Salix phlebophylla; Dryas octopetala; moss/lichen mat. Exposed rocks, many lichens are dead or dying.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-3 A1	Dark brown (10YR 3/3) organic fine sandy loam; breaks to weak fine granular structure; moist; friable; cobble size material protrudes to surface; roots abundant. Abrupt, ruptic boundary.
3-10 E	Yellowish brown fine sandy loam; moist; friable; breaks to weak fine granular structure; iron stains on bottom of large fragments; cobbles > 50% and interrupting the horizon. Clear, wavy boundary.
10-20 B21	Brown (10YR 4/3) fine sandy loam; single grain; moist; cobbles > 50%; roots abundant; continuous iron stains on cobble bottoms. Abrupt, wavy boundary.
20-36 BC	Dark greyish brown (2.5Y 4/2) coarse sand; single grain; moist; roots common; cobbles > 60%; brown (10YR 4/3) silt coats on top of fragments; continuous iron stain on cobble bottoms. Abrupt, wavy boundary.
36-61 C1	Olive grey (5Y 4/2) coarse sand; single grain; moist; cobbles > 60%; silt coats absent; iron stains on lower side of coarse fragments. Profile terminated.

Site:	Atigun Canyon HR5111-3342
	Alluvial fan
Slope:	2%
Vegetation:	*Betula exilis*; *Salix* sp. moss mat, scattered *Carex* sp.
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-3 A1	Dark reddish brown (5YR 3/3) silt loam; friable; weak fine granular structure; cobbles 20%; roots common. Clear, smooth boundary.
3-12 B2	Strong brown (7.5YR 5/6) gravelly silt loam; friable; weak fine granular structure; coarse fragments > 70%; few roots. Clear, wavy boundary.
12-21 C1	Dark brown (7.5YR 3/4) gravel; loose; large fragments have complete iron coats on lower side; sporadic silt coats on top side; few roots. Clear, wavy boundary.
21-57 C2	Dark greyish brown (2.5Y 4/2) gravel; loose; cobbles > 80%; thick, continuous silt coats on upper surface; iron stains on under side; few roots. Clear, wavy boundary.
57-76 C3	Dark greyish brown (2.5Y 4/2) gravel; cobbles > 80%; silt coats discontinuous; sporadic iron coats; roots absent. Profile terminated.

Site:	Atigun Canyon HR5111-3346
	Alluvial fan; microrelief approximately 1 m; few boulders exposed.
Slope:	2%
Vegetation:	Betula exilis; Salix reticulata; Oxytropis sp; Dryas octopetala; Vaccinium uliginosum; moss
Classification:	Pergelic Cryorthent
Depth/Horizon (cm)	
0-1 A1	Dark brown (7.5YR 3/2) organic silt loam. Abrupt, smooth boundary.
1-5 B21	Brown (10YR 4/3) silt loam; friable; weak fine granular structure; roots common. Abrupt, smooth boundary.
5-13 IIC1	Dark greyish brown (10YR 4/2) gravelly fine sand; loose; roots common. Abrupt, smooth boundary.
13-15 IIIA1b	Dark greyish brown (2.5Y 4/2) fine sandy loam; friable; weak fine subangular blocky structure; 10% cobbles; scattered organic fragments. Abrupt, smooth boundary.
15-33 IVB2b	Very dark greyish brown (2.5Y 3/2) gravelly coarse sand; cobbles > 50%; sporadic iron and carbonate precipitation lower side; greyish brown (2.5Y 5/2) silt coats on upper surface; roots common. Abrupt, wavy boundary.
13-74 IVC2	Very dark greyish brown (2.5Y 3/2) gravelly coarse sand; cobbles > 80%; continuous greyish brown (2.5Y 5/2) silt coats on upper surface of cobbles; sporadic iron

Depth/Horizon (cm)	
	stains and carbonate crusts on under side; few roots. Abrupt, wavy boundary.
74-89 VAlb	Black (5Y 2/2) gravelly sandy loam; friable; cobbles > 50%;organic fragments are common. Profile terminated.

Site: Atigun Canyon HR5111-136

Alluvial fan.

Slope: 2%

Vegetation: <u>Betula exilis</u>; <u>Salix</u> sp. moss

Classification: Pergelic Cryorthent

Depth/Horizon (cm)	
0-4 A1	Black (10YR 2/1) organic silt loam; loose; weak, fine granular structure; roots common. Abrupt, wavy boundary.
4-9 IIB2	Very dark greyish brown (10YR 3/2) gravelly sandy loam; loose; cobbles > 50%; discontinuous iron stain on lower side of cobbles; few roots. Clear, wavy boundary.
9-22 IIC1	Very dark greyish brown (2.5Y 3/2) gravelly sandy loam; loose; cobble fragments > 70%; thin discontinuous silt coats on upper surface; iron stain on underside; few roots. Gradual boundary.
22-43 IIIC2	Olive grey (5Y 4/2) gravel; loose; thick continuous silt coats; iron stain on lower side; few roots. Gradual boundary.
43-91 IIIC3	Olive grey (5Y 4/2) gravel; open boxwork; moist; continuous silt coats on upper surface; discontinuous iron coats on lower side. Profile terminated.

Appendix C

Area (% of Total) summary for all soil-landform map units appearing in Fig. 44.

Map Unit	% of Area	Map Unit	% of Area
1-2,4,2	.4	5-1,6,4	1.3
1-2,4,3	.9	5-1,7,2	10.5
1-2,9,2	.1	5-1,9,2	1.1
1-2,9,3	.9	5,5,2	.7
1-2,9,4	2.1	5,5,3	4.3
1-2,9,5	1.3	5,6,3	.3
1-2,9,6	.4	5,8,2	1.0
1-3,16,5	1.0	5,10,3	.2
1-3,16,7	1.9	5,17,6	1.8
1-5,6,2	2.2	5,19,5	.7
1-14,2	.1	6,1,1	4.4
1,2-9,4	.9	12,4,3	.5
1,2,1	1.7	12,4,4	.7
1,2,2	.5	12,4,5	.1
1,3,1	1.2	12,9,2	1.0
1,4,3	.2	12,9,3	1.7
1,4,5	.04	12,9,4	.6
1,9,4	.2	12,9,5	2.0
1,9,5	.7	12,15,4	.2
1,14,3	.1	15,12,5	1.9
1,14,4	1.7	16,6	.03
1,18,4	.8	17.6	.2
3-1,13,4	.1	18	.2
3-1,13,5	1.6	19	16.2
3,11,3	.2	21,9,3	3.5
3,15,5	.3	31,16,3	2.5
4-1,9,5	.3	31,16,5	2.3
4-1,10,4	2.0	45,12,3	.9
4-3,13,6	1.0	45,16,5	.5
4,6,2	.1	54,5,2	.1
4,6,4	3.1	123,9,5	.3
4,9,5	.4	133 ?	.4
4,10,2	.4	135,12,5	1.1
4,11,1	.02	143,9,6	.5
4,11,2	.04	354,14,5	.1
4,12,3	.4	D	.3
4,14,5	.7	Rx	.1
4,17,7	.2		.8
4,18,5	2.4		1.7
4,18,6	.4		

Treeline Site

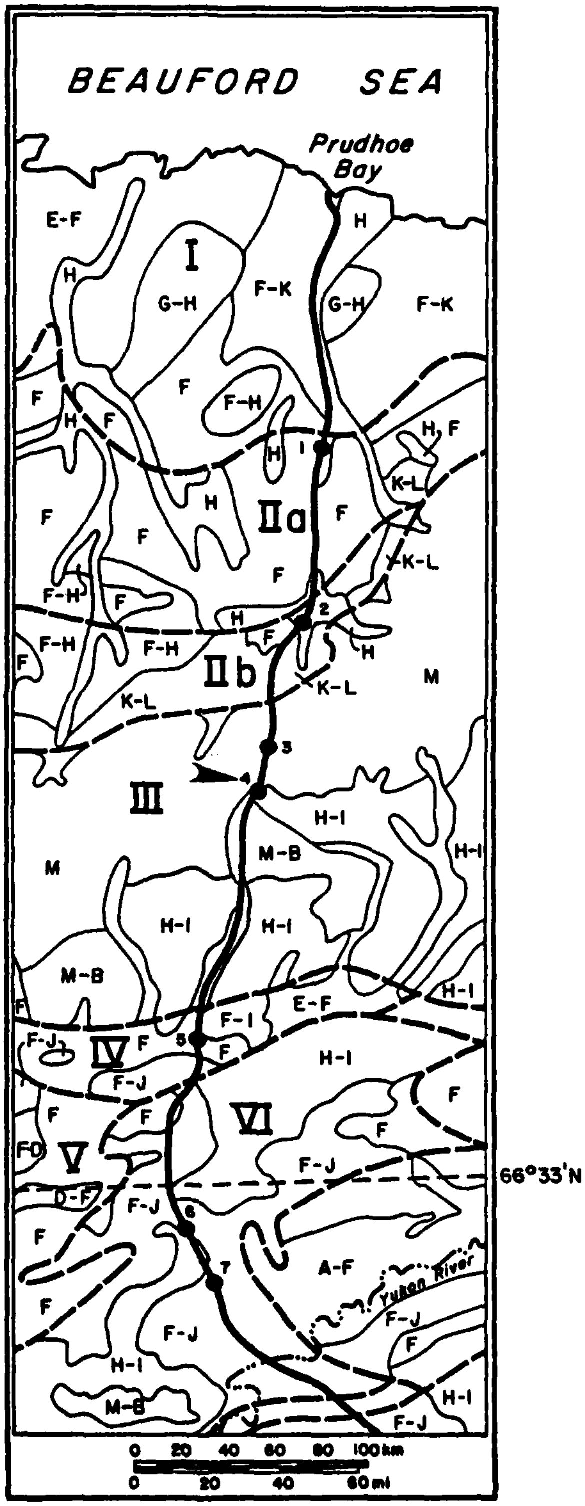


Fig. 54. Location of Treeline site (4) with respect to regional physiographic and soils boundaries. See Fig. 10 for legend.

Physical Geography

Geology

The Treeline site lies 13 km south of the Continental Divide (Fig. 1) in an area underlain mostly by Devonian slate, phyllite and siltstones Kachadoorian (1971) with minor amounts of chloritic slate and phyllite. Thin bedded micaceous silty limestones and massive schistose marble make up the higher landscape on the west side of the Dietrich River Valley but beyond the limits of the study area. The lower valley walls that compose most of the study site are mantled by colluvium consisting mostly of slate and phyllite fragments and weathering products. A discontinuous narrow gravel terrace occurs a meter or so above the alluvium of the present stream. Bedrock is exposed sporadically in the stream bed.

Topography and surface forms

Topographically the Treeline site transects the narrow headwater reach of the Dietrich River (Fig.55). The valley bottom is near 800 m. Soils were described on collivial slopes and bedrock outcrops to an elevation of a little over 1000 m. The cross-sectional slope of the main valley is typical of glaciated mountain valleys. The east-facing slopes are composed of both colluvial and steep alluvial fan materials that are being actively eroded by the river. The opposite slope consists of a steep upper portion (35-40%) decending from and between rock outcrops to a much gentler (15%) slope supported perhaps by a bedrock terrace (Figs. 55and56). All portions of these slopes have well developed (1-1.5 m)

solifluction lobes and sheets. These features are less pronounced on the lower slope where tussock microrelief and frost scars predominate. Mud-flows both active and stabilized are common to the steeper slopes where water and debris is channeled between outcrops.

Permafrost

The entire region of the study site is within the zone of continuous permafrost. It is probable that the lower, colluviated and vegetation covered slopes have ice rich permafrost. The TAPS pipe is above ground throughout much of the study area where it crosses the toes of colluvial slopes or the low elevation old gravel terrace (Fig. 56) indicating ice rich permafrost in the area. August active layer thicknesses were generally in excess of 1 m on steep slope elements and in the gravel terrace remnants. On the tussock frost scar slope the active layer ranged from 15 to 50 cm depending upon the microrelief feature probed. Thick naled ice was observed underlying about 50 cm of soil on an alluvial terrace near the river and is probably seasonal.

Vegetation

As the site name implies it is located at the northern limit of trees, at least for the Dietrich River Valley. Unlike many montane tree lines where trees become progressively more stunted and eventually occur only as Krummholz before being replaced altogether, treeline in the Brooks Range is marked by erect, well formed white spruce. In the study area which crosses treeline, dense stands of white spruce (*Picea glauca*) spread up the southeast-facing slope (Fig. 55). Small groups of white spruce also

Fig. 55. Photo covers the area studied at Treeline. View is to the south. White spruce forest is confined to southeast facing slope (center of photo). Tussock tundra and solifluction slope is to the east of the road, left center and foreground. Soil profile location indicated by profile number (see Appendices A and B).

Fig. 56. View of west-facing frost scar - tussock and solifluction slope at Treeline. Larger structured, darker vegetation is alder. Bedrock outcrops occur along interfluve in photo center and are separated by solifluction slopes. Lower part of slope (lower 1/3 of photo) is seen in Fig. 56 as area east of road. Soil profile location indicated by profile number (see Appendices A and B).

A few trees extend beyond the general tree limit in the valley but are confined to near valley bottom positions. Seedling establishment was observed several hundred meters beyond the last tree. Alder and poplar communities are common on the valley bottom terraces and in some of the more stable mudflow channels. Empetrum eamesii, Vaccinium vitis-idaea, and Cladonia spp. compose the understory of the spruce community (Walker and Webber, 1979).

The northeast-facing slope is dominated by a sedge (Eriophorum vaginatum), and small shrub (Salix planifolia) tundra in which scattered alders, some in excess of 2 m are common. Near the river and in some of the tributary stream channels Salix alaxensis occurs along with alder to form a dense community. Higher on the slopes, dense communities of alder can occur on stabilized talus.

The southeast facing slope north of treeline supports a community composed of Salix lanata, Betula glandulosa and Ledum palustre as well as mosses and lichens. Alder thickets are common to the narrow, boulder floored stream valleys.

Soils

One of the outstanding characteristics of the treeline site is slope instability. This is reflected in the abundance of solifluction forms, and debris flows especially on steeper slope segments combined with frost scars on the flater slopes. The development and maintenance of these forms is related to the phyllitic bedrock which is easily weathered and produces rather significant percentages of bedrock derived clay size materials and micas. Under conditions of rapid mass movement soils, as

such, are absent or very shallow on the higher and/or steeper slopes. Most are Entisols or, in cases where there is some site stability, Lithic Cryochrepts. The steep colluvial or colluviated talus slopes have a complex of Histic Pergelic Cryaquepts (commonly associated with the fronts or risers of solifluction lobes), Pergelic Cryaquepts which characterize tussock frost scar tundra and areas behind and between the solifluction forms (Profiles 286.1 A and B, Fig. 56). Somewhat drier sites commonly interfluve elements of these slopes, have Pergelic Cryorthents or rarely Pergelic Cryochrepts (Profile 285.1, Fig. 56) - slopes in most cases exceed 20%. Soils with thick organic horizons, in some cases approaching 40 cm may occur where mass movement has doubled-over the organic surface horizons. Well drained soils on relatively stable upland and/or outcrops (Profile 287.5, Fig. 56) are rare and are considered cryorthents primarily on the morphologic differentiation of their profiles. These soils are leached as shown by a regular decrease in soil reaction with depth to the C horizon. The regular decrease in exchangeable cations and organic carbon also supports leaching. Some amount of iron and alluminum concentration has taken place in the B horizons and a significant proportion of this is associated with translocated organic compounds (see Appendix A). Clay mineral analysis does not indicate any substantial weathering or synthesis of these minerals (pg. 348).

The valley bottom gravel terraces are generally poorly drained and have Pergelic Cryaquept soils. Organic horizon thicknesses are seldom sufficient however, to permit the term Histic to be applied.

Soils beneath the spruce forest form a complex of Pergelic Cryorthents and Pergelic Cryaquepts. Profiles commonly are bisequal attesting to

multiple erosion and deposition events on these colluvial slopes. Although solifluction forms do occur, blowdown mounds are by far more important in profile desruption. As a general rule the Pergelic Cryorthents occur on relative better drained sites that are also more heavily forested. Wetter, sedge dominated areas have Cryaquepts (Profile 285.2 and 285.3, Fig. 55), however, wetness characterizes nearly all profiles below 25 to 30 cm (Appendices A and B). South of treeline Pergelic Cryorthents are the principal soils of the steep solifluction slopes.

The east-facing, forested, slope has been subjected to fire at some time in the past as evidenced by charcoal fragments in the upper part of some profiles examined just beyond the treeline. No other eivdence for fire was seen and, judging by the ages obtained for valley bottom spruce the area probably has not burned for several hundreds of years.

Soil associations of the treeline site are representative of steeper portions of mountain slopes along much of the haul road. Somewhat farther south the tussock-frost scar slopes support stands of black spruce (_Picea mariana_)and Histic Pergelic Cryaquepts become a significant component in the soil complex (see Tramway Bar site, pg. 230). As valley bottoms become broader, old terrace and bar deposits with open white spruce-birch-lichen woodlands are common and Pergelic Cryochrepts with well defined profile morphology are developed.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soil/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount ($<$ 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophosphate extraction
VC	Very coarse sand 2-1 mm; C coarse sand 1-0.5 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class:	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam; silty clay loam.

Treeline
Selected Edaphic Characteristics

Soil Profile	depth (cm)	horizon	color	% organic carbon	Ca^{+}	Mg^{++}	K^{+}	Fe% DC	Fe% OX	Fe% SP	Al% DC	Al% OX	Al% SP	pH	Sands VC	Sands C	Sands M	Sands F	Sands VF	Sands T	Silt C	Silt F	Clay C	Clay F	Text. Class
287.5	0-2	A1	10YR3/1	7.3										6.1	15	14	6	17	9	61	17	12	9	1	CSL
	2-6	E	10YR3/2	4.0	3.1	1.6	0.32	1.60	0.98	0.29	0.29	0.16	0.14	5.8	12	13	6	17	10	58	14	16	11	2	CSL
	6-14	B21	10YR5/4	1.1	0.4	0.3	0.09	1.26	0.62	0.22	0.20	0.15	0.13	5.5	21	14	6	11	7	59	10	21	9	1	CSL
	14-23	B3	2.5Y5/4											5.5	30	16	6	11	6	68	8	14	10	T	CSL
	23-44	C	2.5Y4/2		0.7	0.9	0.05	0.87	0.28	0.04	0.09	0.07	0.03	6.1	30	24	9	15	7	81	7	7	5	T	LCS
285.1	0-3	O1	7.5YR3/2	28.8																					
	3-20	B21	10YR6/4		0.9	0.6	0.42	1.95	0.23	0.45	0.29	0.21	0.26		17	9	3	9	9	47	8	24	20	1	L
	20-33	BC	10YR5/4		1.0	0.9	0.18	1.39	0.17	0.22	0.25	0.15	0.19		27	16	5	9	6	63	6	16	15	1	CSL
	33-58	C1	10YR5/3		2.5	2.2	0.08	1.18	0.13	0.06	0.14	0.11	0.05		34	18	5	8	5	71	1	14	13	T	CSL
285.2	0-5	O1	10YR3/3	41.7																					
	5-13	A1	5YR2.5/2	31.8																					
	13-26	IIC1	2.5Y4/2																						
	26-42	IIC2	5Y4/1																						
285.3	3-0	O1																							
	0-18	C1	5Y4/2		4.1	2.0	0.09								41	19	6	7	4	76	3	11	9	1	CSL
	18-20	A1	5Y4/2	3.5																					
	20-28	IIC2	N5/												41	23	7	9	3	82	2	9	7	T	LCS
	28-34	IIIB21g	N5/		8.6	3.6	0.10								1	1	1	7	15	24	20	38	15	4	SIL
	34-38	IVA1b	5YR2.5/1	21.2																					
	38-48	IVC3g	5Y5/2		7.4	3.1	0.08								12	10	4	9	8	44	8	28	19	1	L
	48-71	IVC4g	5Y4/2												16	12	5	10	7	50	10	21	18	2	L
285.0	0-4	O1	10YR2/2																						
	4-8	A1	10YR2/1	32.3																					
	8-31	BC	10YR4/2		6.6	3.0	0.11	0.81	0.13	0.15	0.15	0.14	0.16		16	9	4	10	8	46	7	26	20	2	L
	31-46	IIC1	2.5Y4/2		5.3	2.4	0.08	0.82	0.16	0.08	0.16	0.19	0.08		24	13	5	10	7	59	6	20	15	1	SL
	46-61	IIC2	10YR4/2												28	16	6	11	7	68	5	16	11	1	CSL
	61-71	IIIC3	10YR2/2																						

Appendix B

Selected profile descriptions of the soils of the Treeline site. Refer to Figs. 55 and 56 and Appendix A for topographic setting and edaphic characteristics.

Site:	Treeline: Profile #285.0 5108
Slope:	25%
Vegetation:	*Salix* sp. (bush form to 1 m); *Alnus* sp.; *Salix reticulata*; moss and grass understory.
Classification:	Pergelic Cryorthent (?)
Remarks:	Temperature at 48 cm, 5.5°C; 86 cm, 2°C
Depth/Horizon: (cm)	
0-4 01	Very dark brown (10YR 2/2) organic; friable; stems and root fragments abundant; structureless; roots abundant. Abrupt, smooth boundary.
4-8 A1	Black (10YR 2/1) organic silt loam; wet; friable; weak coarse subangular blocky; roots common. Abrupt, smooth boundary.
8-31 BC	Dark greyish brown (10YR 4/2) gravelly clay loam; moist; friable; weak coarse angular blocky structure; fine faint (10YR 5/6) mottles; roots common. Abrupt, smooth boundary.
13-46 IIC1	Dark greyish brown (2.5Y 4/2) fine gravelly clay loam; moist; friable; 30% coarse fragments up to 5 cm in size; fragment bottoms clean and wet; fragment tops have clay coats; few roots. Abrupt, smooth boundary.
46-61 IIC2	Dark greyish brown (10YR 4/2) fine gravelly silty clay loam; wet; friable; slightly sticky; water conducting; roots few to absent . Abrupt, smooth boundary.

Tree: Profile #285.0 5108

Depth/Horizon (cm)	
61-71 IIIC3	Very dark brown (10YR 2/2) silty clay loam; wet; friable; slightly sticky; fine gravel; inclusions of organic dark brown (7.5YR 3/2); few roots; profile terminated due to water. Permafrost 109 cm.

Site:	Treeline: Profile#285.1 5108
Slope:	Stable slope partially denuded 38%
Vegetation:	Betula sp. patches with Vaccinium vitis-idaea; Artemisia sp.; lichens.
Classification:	Pergelic Cryochrept
Depth/Horizon: (cm)	
0-3 01	Dark brown (7.5YR 3/2) organic loam; turfy; dry; loose; breaks to weak very fine granular; many stem fragments; few manganese concretions 1-2 mm; roots common; coarse fragments < 10%. Abrupt, smooth boundary.
3-20 B21	Light yellowish brown (10YR 6/4) micaeous silt loam; moist; loose; fine granular structure; coarse fragments > 50%; large fragments approximately three inches in diameter have thin discontinuous brownish yellow (10YR 6/6) silt or clay coats on top and weak sporadic iron stains on the bottom; roots common. Clear, smooth boundary.
20-33 B22 (BC)	Yellowish brown (10YR 5/4) micaceous silt loam; moist; loose; weak fine granular structure; coarse fragments 80%; roots common; brown (10YR 5/3) silt clay coats 70% continuous iron stains on bottom. Abrupt, smooth boundary.
33-58 C1	Brown (10YR 5/3) shaley fine gravel; fine earth clay loam; moist; loose; few roots; thick silt/clay coats 60%; sporadic iron stains on bottoms. Profile terminated. 20 August 1977.

Site:	Treeline: Profile#285.2 5108
Slope:	Mid Slope 16%
Vegetation:	Spruce (Pica glauca) with scattered Salix spp.; Betula grandulosa s c a t t e r e d Vaccinium uliginosum; Empetrum nigrum; lichens and moss.
Classification:	Pergelic Cryorthent
Depth/Horizon: (cm)	
0-5 01	Dark reddish brown(10YR 3/3) fibric moss mat. Abrupt, smooth boundary.
5-13 A1	Black (5YR 2.5/2) organic silt loam; < 20% coarse fragments; root and stem fragments common. Abrupt, smooth boundary.
13-26 IIC1	Dark greyish brown (2.5Y 4/2) clay loam; structureless; moist; loose; very few roots; coarse fragments 80% shaley gravel with 30% cobble size. Aburpt, smooth boundary.
26-42 IIC2	Dark grey (5Y 4/1) clay loam fine earth; fine to medium gravel; 50% coarse fragments cobble size; no roots; cobbles have thin, continuous olive grey (10YR 5/2) silt coats and sporadic iron stains on bottom. Profile terminated. 20 August 1977.

Site:	Treeline: Profile #285.3 5108
Slope:	25% Mid slope north-facing.
Vegetation:	Spruce; deciduous trees with grasses and moist understory. Scattered _Salix_ sp.; _Petasites frigidus_; _Salix reticulata_ and Alder.
Classification:	Pergelic Cryaquept ? (Orthent ?)
Depth/Horizon: (cm)	
3-0 01	Moss vegetation and organic litter composed of leaves; stems; root fragments; few roots. Abrupt, smooth boundary.
0-18 C1	Olive grey (5Y 4/2) clay loam; 80% phyllitic platy fine gravel; weak fine crumb structure; moist; loose; few roots. Abrupt, smooth boundary.
18-20 A1	Dark grey (5Y 4/2) organic clay; buried organic (identifiable grass stems and leaves); few roots. Abrupt, smooth boundary.
20-28 IIC2	Grey (N 5/) fine platy gravel; moist; loose; structureless; few fines; no silt coats; few organic fragments; no roots. Abrupt, smooth boundary.
28-34 IIIB21g	Grey (N 5/) clay; coarse fragments < 20%; wet; structureless; slightly sticky; many fine faint light olive brown (2.5Y 5/4) mottles; mottles appear to be related to decomposing moss fragments. Abrupt, smooth boundary.

Treeline: Profile # 285.3 5108

Depth/Horizon: (cm)	
34-38 IVA1b	Black (5YR 2.5/1) organic silt loam; root fragments common. Abrupt, smooth boundary.
38-48 IVC1g	Grey (5Y 5/2) clay loam; moist; loose; moderate medium subangular blocky; coarse fragments 60%; stem fragments common; no roots; many medium distinct dark yellowish brown (10YR 4/6) olive yellow (2.5Y 6/8) mottles. Abrupt, smooth to wavy boundary.
48-71 IVC2g	Dark grey (5Y 4/2) clay loam; coarse fragments 60%; wet; sticky; many root and stem fragments mixed in horizon; few fine faint yellowish red (5YR 5/6) mottles. Profile terminated, water entered pit.

Site:	Treeline Profile #286.1 A 5108
Slope:	15% Tussock slope with scattered frost scars.
Vegetation:	Tussocks; Eriophorum vaginatum; Ledum palustre; Betula sp.dominate in inter tussock space with moss and lichens. Scattered Carex; Vaccinium vitis-idaea; Petasites frigidus.
Classification:	Pergelic Cryaquept (frost scar element of pedon)
Depth/Horizon (cm)	
0-8 B2g	Brown (10YR 5/3) silty clay loam; moist; friable; slightly sticky; common fine distinct yellowish brown (10YR 5/8) mottles; roots common. Abrupt, wavy boundary.
8-41 B22g	Olive grey (5Y 4/2) silty clay loam; wet; slightly sticky; thixotropic; moderate medium platy structure; common coarse prominent strong brown (7.5YR 4/6), and light olive brown (2.5Y 5/6) mottles; few roots. Clear, ruptic boundary.
41-51 C1	Dark grey (7.5YR N/4) silty clay loam; wet; slightly sticky; moderate medium platy structure; common medium distinct light olive brown (2.5Y 5/4) and very dark grey (2.5Y 3/4) mottles; root and stem fragments common; no live roots. Profile terminated, permafrost at 51 cm. 23 August 1976.

Site:	Treeline: Profile#286.1 B 5108
Slope:	16% mid slope
Vegetation:	<u>Eriophorum</u> <u>vaginatum</u>
Classification:	Pergelic Cryaquept. Tussock element of pedon. See profile 286.1 A.
Depth/Horizon: (cm)	
8-0 O1	<u>Eriophorum</u> <u>vaginatum</u>/grass
0-15 O1	Greyish brown (2.5Y 5/2) organic silt loam; tussock core many live and dead roots. Abrupt, smooth boundary.
15-41 C1g	Dark greyish brown (2.5Y 4/2) silt loam; wet; not sticky; moderate, fine to medium crumb structure; thixotropic; many medium distinct light olive brown (2.5Y 5/6) and yellowish brown (10YR 5/8); very dark grey (10YR 3/2) mottles; many roots. Clear, wavy boundary.
41-43 C2g	Very dark grey (10YR 3/2) organic silt loam; wet; slightly sticky; moderate medium platy structure; many root and stem fragments. Clear, wavy boundary.
43-56 C3g	Dark grey (5Y 4/2) silt loam; wet; slightly sticky; weak fine platy to weak fine crumb structure; common medium distinct olive (5Y 4/4) and dark grey (10YR 4/1) mottles; thixotropic; coarse fragments < 5%. Permafrost at 56 cm.

Site:	Treeline Profile #286.1 C 5108
Slope:	16% Tussock slope with scattered frost scars.
Vegetation:	Tussocks; Eriophorum vaginatum; Ledum palustre; Betula exilis dominate in inter tussock space with moss and lichens. Scattered Carex; Vaccinium vitis-idaea; Petasites frigidus.
Classification:	Histic Pergelic Cryaquept (moss inner space between tussocks, see profiles 286 A and B.
Depth/Horizon: (cm)	
8-0 Oi1	Leaf,moss litter; mostly dead moss; some live moss; Abrupt, smooth boundary.
0-5 Oi2	Dark reddish brown (5YR 3/2) fibrous moss and Carex fragments; wet; loose. Clear, smooth boundary.
5-13 Oi3	Dark reddish brown (5YR 3/2) to reddish yellow (7.5YR 7/6)fibrous organic; wet; loose; mostly moss fragments. Clear, smooth boundary.
13-15 Oe1	Black (5YR 2/5/2) hemic organic; wet; stems and root fragments common. Frozen. 23 August 1976.
15-23 Oi4f	Frozen fiberous peat.
23+ C1gf	Frozen mineral; matrix brown (10YR 5/3); many coarse distinct reddish brown (5YR 4/4) yellowish brown (10YR 5/6) mottles.

Tramway Bar Site

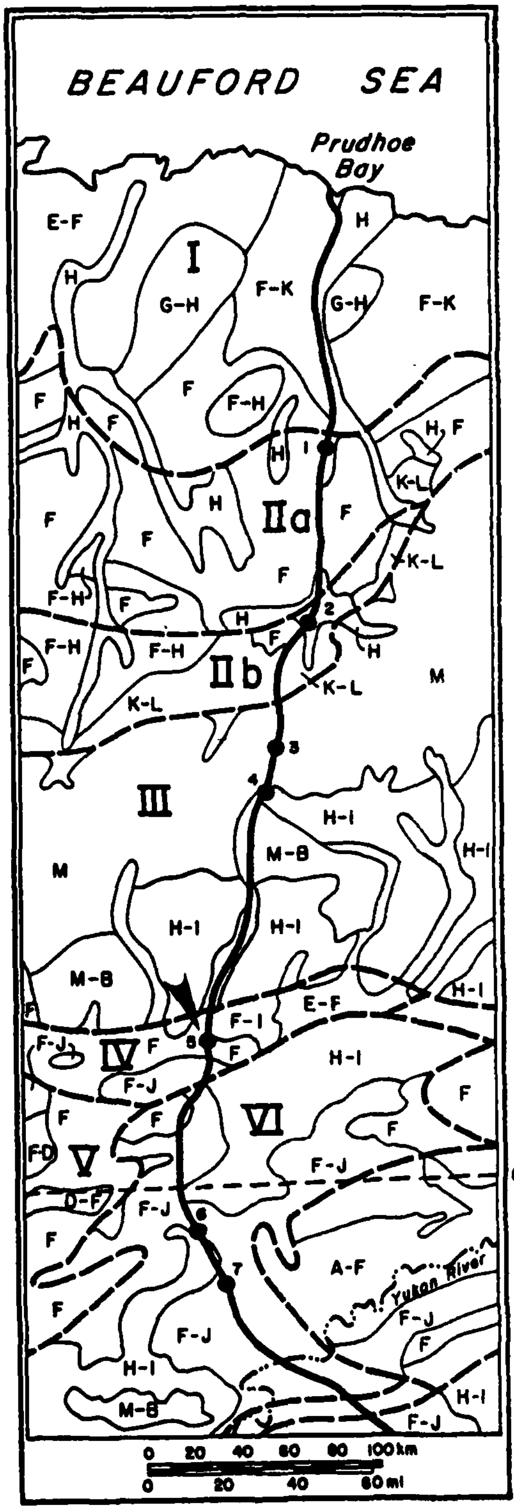


Fig. 57. Location of Tramway Bar site (5) with respect to regional soils physiographic and boundaries. (See Fig. 10 for legend).

Physical Geography

Geology

The Tramway Bar site is situated in the Chandalar Ridge and Lowland a section of the Intermontane Plateaus Province some 115 km south of the Continental Divide (Fig. 1) Wahrhaftig, 1965). It is between 10 to 15 km north of the Itkillik terminal moraine (Hamilton and Porter, 1975) on a kettle moraine complex (Kachadoorian, 1971). The materials of this complex are rounded to subrounded gravels representing the range of lithologies of the central southern parts of the Endicott Mountains. In general the gravels have relatively low volumes of sands and finer materials. These deposits are probably largely of Itkillik I age (24,000 to 17,000 yr. B.P., Hamilton and Porter, 1975). Variable thicknesses of loess cap higher areas of the moraine complex and some of the side slopes. Dissection of the complex took place during its formation and to some extent after.

Topography and surface forms

The map area and much of the surrounding region is composed of narrow, often discontinuous gravel ridges that rise 10 m or somewhat more above the surrounding bog meadows. The general elevation of the meadows is close to 345 m.

The pattern of ridges is generally east-west. Small kettle lakes and ponds occur between or are surrounded by the ridges. Most of the bog meadows are traversed by narrow streams, some of which may be a meter or more deep. Occasionally, nearly circular thermokarst pools may interrupt a drainage and reach depths of > 2 m. During melt-off the larger streams

probably carry significant amounts of water and suspended debris that contribute to low natural levees. Regional drainage is to the west and southwest into the Middle Fork of the Koyukuk River.

Peat islands are common features of the bog meadows (Fig.58). The larger islands reach several hectares and rise a meter above the surrounding fen.

A colluvial slope of widely ranging width forms the transition between the ridges and the bog meadows. The materials that compose these slopes become finer grained (silt or finer) only a short distance from the base of the ridge slope. A ridge and swale pattern (stripe pattern) with up to 0.5 m relief is common to the transitional slopes. Some stripes are sites of frost scars. Often, areas of large tussocks mark the lower part of these slopes. Tussock spacing of 40 to 60 cm with 60 cm microrelief is common.

Some gravel ridges are relatively broad and poorly drained particularly those with slightly concave profiles. Small, shallow, partly water filled pits or depressions are common to such ridges and may represent thermokarst development induced by fire on small kettles produced as ice blocks melted sometime after deposition of the outwash.

Permafrost

The Tramway Bar area lies very near the southern margin of the region of continuous permafrost (Ferrians, 1965). The relatively warm continental summers south of the Brooks Range permit thawing to 1.50 m or more in the gravelly soils of south facing ridge slopes. Mid-August temperatures of 7°C at 90 cm are not uncommon. On transitional slopes thaw reaches 41 cm

Fig. 58 . Portion of a peat plateau (map unit 45, P. 1) acid *Sphagnum* sp. peat (left) rises 1 m above adjacent alkaline sedge fen. This association is typical of bog meadows, map unit (4, 6, 2) upper center and right in photograph. An area of well-drained out-wash gravels (map unit 3, 3, 5) can be seen in extreme upper left.

in stripes having only a few centimeters of organic material at the surface and 23 cm in adjacent swales with thick organic horizons (see Fig. 64, pg. 234). In bog meadows permafrost depth is variable depending upon moisture conditions and the amount of organic soil. In Palsas for example, ice rich permafrost is encountered in August at 40 cm and massive segregation ice in some cases below 150 cm while in the adjacent wet Carex fen permafrost may be 60 cm or more. Large volumes of ice are probably common below the meadow surfaces. Other manifestations of high ice permafrost include ice wedge polygons apparent in some localities (see Fig.66) and isolated thermokarst pools or beads.

Although tussocks are very well developed in the area frost scars are not common except on the sloping and somewhat better drained sites. August permafrost in these areas ranges between 40 cm and 62 cm.

Vegetation

The Tramway Bar site is within the open, low growing spruce forest vegetation type (Viereck and Little, 1972). Slope break areas rimming the gravel ridges (Fig.62) and to some extent steep south-facing slopes below the ridges support an open stand of Alaskan Paper Birch (Betula papyrifera), Quaking Aspen (Populus tremuloides) and scattered White Spruce (Picea glauca). Alder (Alnus sp.) and Prickley rose (Rosa acicularis) are common understory species. The ground cover is a mat of Cladonia alpestris, Vaccinium vitis-idea and Empetrum eamesii (see Fig.63).

Transitional slopes (Fig.63) are characterized by Black Spruce (Picea mariana) which become increasingly stunted and widespread as the bog meadow is approached. In the same direction tussocks of Eriophorum

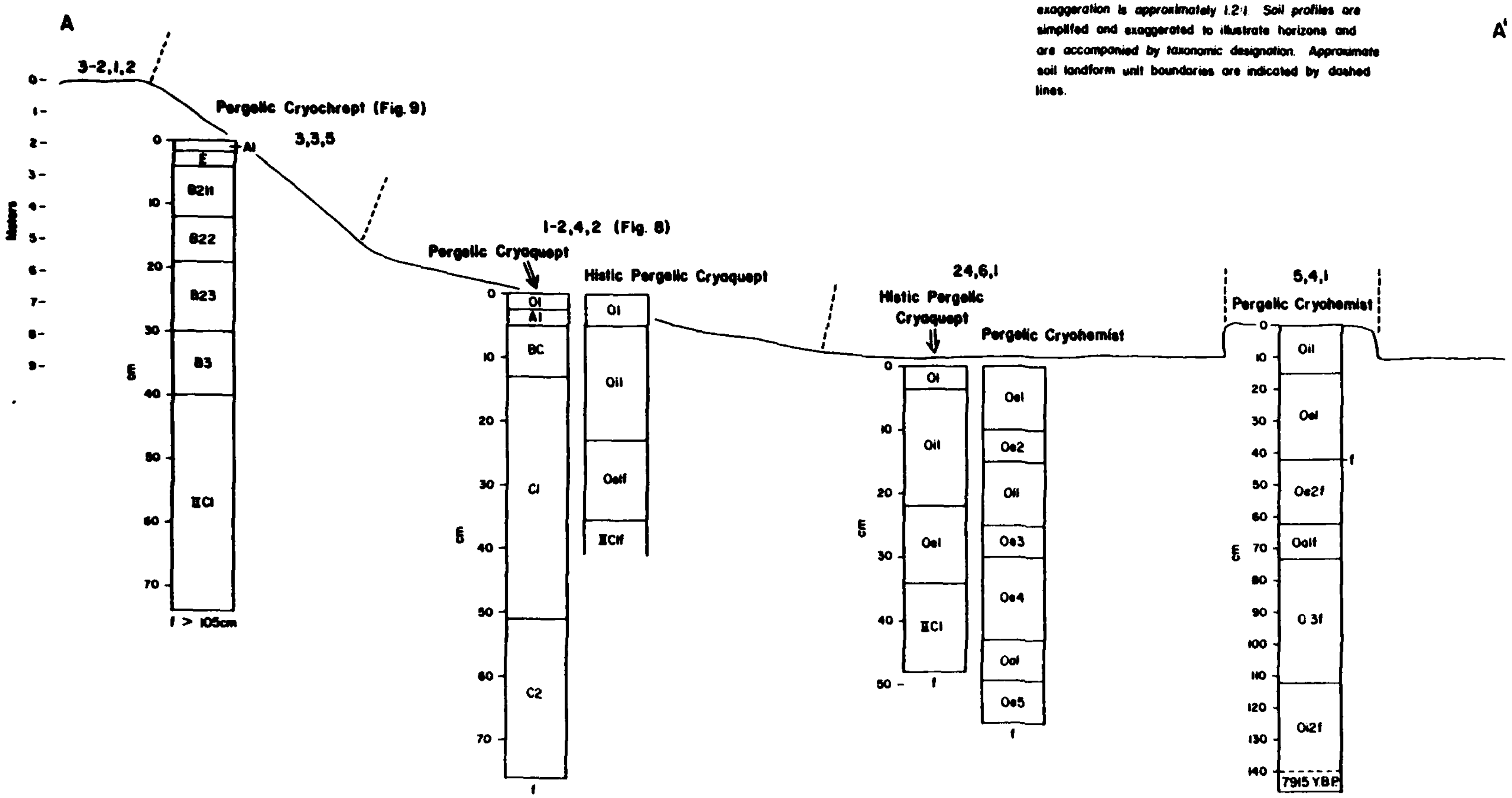


Fig 59 Schematic cross-section showing soil landform relations for some of the princial units in Fig 58 Vertical exaggeration is approximately 1.2:1. Soil profiles are simplifed and exaggerated to illustrate horizons and are accompanied by taxonomic designation. Approximate soil landform unit boundaries are indicated by dashed lines.

Fig. 60. Narrow crest of dissected outwash in which Pergelic Cryochrepts or Pergelic Cryorthents develop. Forest aspect is rather open. Ground cover is *Cladonia* sp.; *Vaccinium vitis-idaea* and *Empetrum eamesii*.

vaginatum increase in abundance and height. Ledum palustre, Vaccinium uliginosum and Rubus chamaemorus become increasingly associated with the tussocks downslope. A fringe of Salix sp. is common at the base of the transitional slope.

Tall Alder shrubs occur as widely spaced individuals on several long southwest-facing slopes dominated by tussocks. Although this association is not common in the map area it is somewhat farther south, e.g., south of Bonanza Creek and on the uplands of the Finger Mountain site.

Picea mariana occurs in the bog meadows as scattered individuals or groups of trees surrounded by Carex aquatilis and Carex sp. fen or a tussock meadow composed of Eriophorum vaginatum, Betula sp., Ledum palustre, Vaccinium uliginosum, Empetrum eamesii and scattered Salix sp. Palsas are raised above the general level of the bog or fen and support thin stands of P. mariana often of good size with an understory of Salix sp., Betula sp. and Sphagnum spp. Natural levees are commonly sites of dense thickets of Salix sp. and Betula sp. or very large tussocks.

The general stunted appearance of the spruce is attributable in a large measure to a combination of permafrost, high water tables and low nutrient supply. The wide age range in trees from one area to another is probably related to forest fires which probably occur at intervals of 80 to 100 years (Barney, 1971).

Soils

The soils on most of the landscape within the Tramway Bar map area (Fig. 66) are poorly or very poorly drained and belong to the Histic subgroup of the Inceptisols or are organic soils (Histosols). Soils of the

SOIL LANDFORM MAP

Mile 103.5 – Mile 104.5 TAPS Haul Road

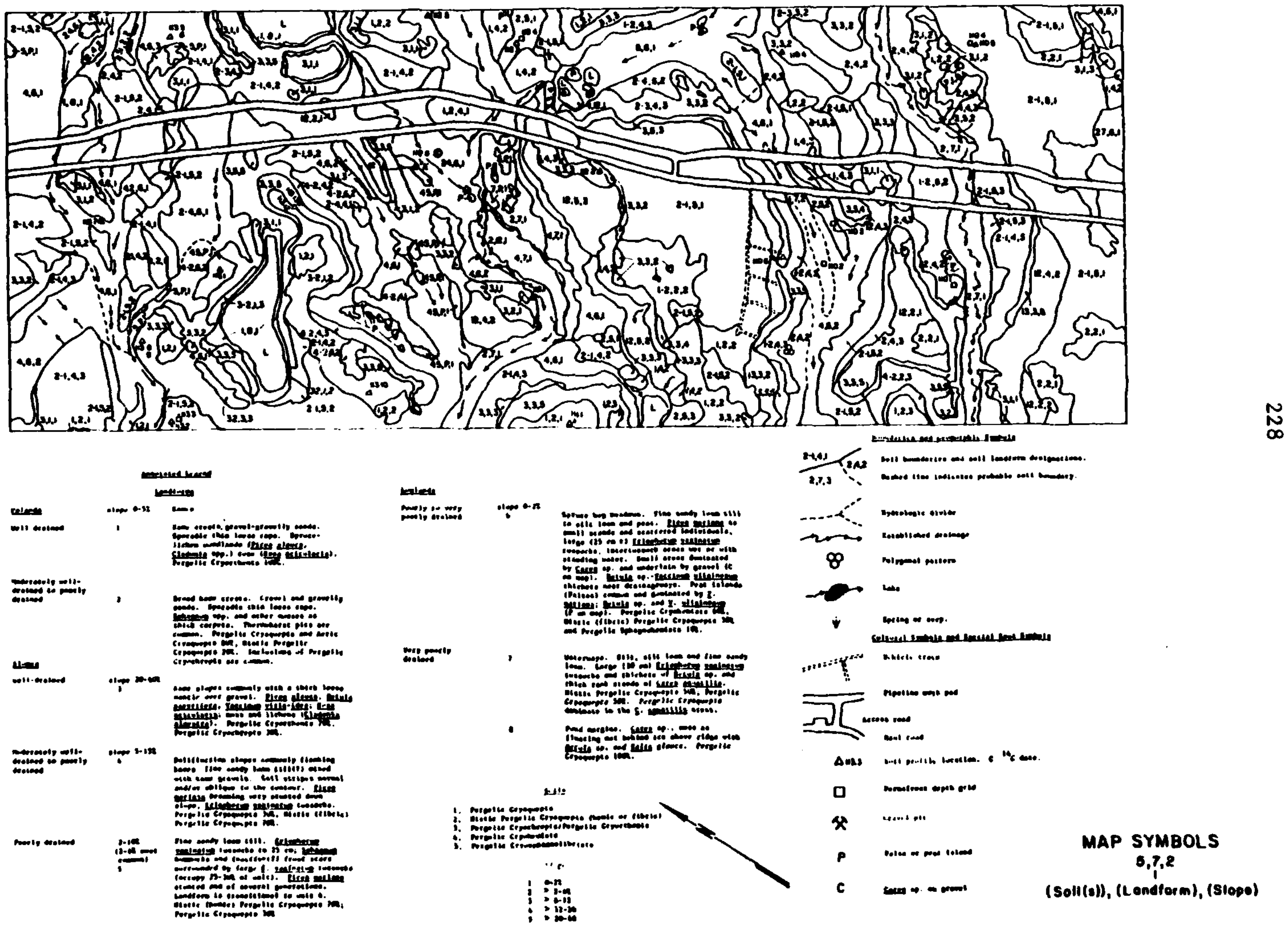


Fig. 61

lower landscape portions e.g., spruce-bog meadows and the mid and lower portions of colluvial slopes surrounding outwash remnants are Histic Pergelic Cryaquepts and/or Pergelic Cryohemists or Pergelic Cryosaprists (Fig.59). Their O horizons are composed predominantly or partially of little decomposed mosses, especially Hylocomium sp. and lesser amounts of Sphagnum spp. These materials have an open spongy structure near the surface but are more layered (compressed) and decomposed with depth. They overlie thixotropic grey silt loam textured mineral materials. Peat islands within the Spruce-bog meadows are composed of organic materials to depths of at least 1.5 m (Fig. 3). The upper 20 cm to 50 cm of the soil is composed almost entirely of Sphagnum peat. Sphagnum remains a significant component throughout the upper 40 cm but with increasing sedges, cf. Carex aquatilis or other species common in the adjacent fens are the principal components of the peat. It is not uncommon to encounter horizons of forest peat, sometimes highly decomposed and containing wood fragments and charcoal or horizons composed of organic material derived from Eriophorum vaginatum tussocks. Throughout the upper tiers of the control section (0 to 80 cm) the state of decomposition is such that the soils are classified as Pergelic Cryohemists. Pergelic Cryofibrists may occur sporadically. It is likely that the changes in botanic composition of the peat and its decomposition state reflect changes in drainage history and to some fire.

Much of the permanently frozen peat contains segregation ice usually as lenses, the thicker ones 0.6 to 2 cm in thickness comprise probably less than 10% of the samples depths (to 1 m). The development of the peat islands will be considered in the next section.

Extensive lowland areas support tussock tundra and widely scattered, solitary, small (young?) Black Spruce trees, soil landform unit 2-1,5,1 (Fig. 59 and 62). Soils of such areas are an association of Histic Pergelic Cryaquepts and Pergelic Cryaquepts. Such tussock "tundra" differs from the tussock tundra of the Foothills Province (see Toolik and Sagwon descriptions) in several significant ways. (1) Tussocks are very large, ranging to > 50 cm (avg. 30 cm) and closely spaced such that the crown of one individual touches its neighbor. (2) The intertussock areas may contain Sphagnum sp. or commonly have only algae at the surface. Frost scars do not constitute a significant component of the landform unit. Soils of the intertussock areas are Histic Pergelic Cryaquepts (either a histic or fibric texture). The Histic epipedon is thick commonly > 30 cm. In some cases where Sphagnum occurs the surface organic materials may exceed 40 cm. The soil is not considered an organic soil however, because in the case of Sphagnum special thickness requirements are envoked (Soil Survey Staff, 1975). The tussocks present a special problem. If they are considered to represent an organic accumulation, (below the living crown and excluding the living roots) their thickness added to that of the organic materials upon which they grow (e.g., the intertussock profile) is sufficient to meet the requirements of a Histosol thus the soil association becomes one of Pergelic Cryohemists (and/or Cryofibrists) and Histic Pergelic Cryaquepts. Frost scar soils are Pergelic Cryaquepts. Mineral soil horizons are silt loams (micaceous silt loam) commonly with a few percent of very coarse sand or small pebbles.

The colluvial slopes that surround outwash remnants, landform unit 1-2, 4, 2,(Figs.59 and63)are usually forested. A stripe pattern

Fig.62 . View typical of soil landform unit 24-1,5,1. Tussocks of *Eriophorum vaginatum* range in height from 18 to 53 cm. with nearly half between 30 and 43 cm. Inter-tussock space is obscured due to overlapping tussock crowns. Shrubs are mostly *Betula* sp., scattered and isolated individuals of *Picea mariana* occur. Forested area is an outwash remnant, map unit 3,3,5.

Fig. 63 . Area pictured above soil-landform unit 2-1, 4, 2 is typical of the transition between soil-landform unit 4, 6, 2 and the steeply sloping outwash, remnants unit 3, 3, 5. Areas of large (≥ 50 cm) tussocks of Eriophorum vaginatum are interspaced with multi-aged Black Spruce. A portion of a discontinuous soil stripe appears in extreme lower right with Cladonia sp. and Empetrum sp. predominate in the vegetation.

characterizes these slopes especially in their mid and upper parts. Soils in the forest areas are Histic Pergelic Cryaquepts, and rarely, Pergelic Cryohemists. The upper 5-10 cm commonly consists of Sphagnum sp. as a spongy carpet. The lower organic horizons consist of little decomposed and compressed Sphagnum or mixtures of Sphagnum and Hylocomium sp. Fine fragments of charcoal are common near the lower boundary. The Histic epipedon generally rests abruptly on micaceous fine sandy loam that contains 5-7% fine gravel. The upper few centimeters of the mineral material is oxidized. Below this zone colors are dark greyish brown (2.5y 4/2) indicative of anoxic conditions.

Continuous to discontinuous lichen dominated stripes, 1 to 2 meters wide cut through the forest normal to the slope. Although in some areas mineral soil is exposed in most cases a thin (8 cm) organic horizon abruptly overlies mottled, micaceous fine sandy loam with fine gravel (the gravel component increases upslope toward the outwash). The mineral portion of these soils (Pergelic Cryaquepts) is mottled throughout. However, as the permafrost is approached gley colors predominate and the materials become thixotropic. The soil association just described is represented in Fig. 64.

Near the base of the colluvial slopes large tussock openings occur. The stripe pattern becomes fragmented. Pronounced frost scars, commonly ringed by large diameter tussocks are common. A complex of Histic Pergelic Cryaquepts, Pergelic Cryaquepts and Pergelic Cryohemists is recognized.

The only well-drained soils in the map area are associated with the topographically elevated outwash remnants (landform unit 3) (Figs. 58 and 59). The soils designated generally as Pergelic Cryochrepts (Inceptisols)

Fig. 64 . Histic Pergelic Cryaquept - Pergelic Cryaquept soil association typical of soil-landform unit 2-1, 4, 2. Profiles represent maximum summer thaw 24 August. Scale shown by 8 x 13 cm card.

have developed under conditions of acid leaching beneath a relatively open stand of _Populus tremuloides_, _Picea glacua_ and a lichen and _Vaccinium_ ground cover (Fig.60). Parent materials in which the soils have formed range widely from place to place in both texture and composition. In some cases the soils have developed in thick loess, in others, especially on the steepest slopes (50%) much of the loess has been washed off or is intermixed with the gravelly sands of the outwash. This presents problems in classification of the soils. In the first case they are Pergelic Cryochrepts (Inceptisols) in the second Pergelic Cryorthents (Entisols). In either case the general profile morphology is similar in that a thin, commonly discontinuous, elluvial horizon occurs between an equally thin organic rich A1 horizon and an oxidized sequence of B horizons. Textures coarsen with depth. These are the warmest and most deeply thawed of the areas' soils with permafrost near two meters,in August, on south-facing slopes.

Less well developed (although probably much older) counterparts of these soils have been described at the northern sites (see Atigun and Sagwon site descriptions). Many of these more northern well-drained soils lack the degree of development of the elluvial horizon, probably as a result of shorter thaw season, lower precipitation and colder soil temperatures.

Where the loess cap remains in place or in areas where it has been thickened by addition from up-slope an increase in clay is noted in the B horizon relative to the overlying elluvial (E) horizon. Such is the case in the profile shown in Figure 65(see analysis, Appendix A). Clay bridges do not occur however, the upper surface of rock fragments are usually coated with silty clay. This phenomena is common even in

Fig.65. Pergelic cryorthent on steep south-facing slope (soil landform unit 3, 3, 5 Figs 59 and 61). Elluvial (E) horizon developed between 6 and 10 cm.

temperate regions and results from entrainment of the fine particles in downward moving water. If leached carbonates are present in the water they are deposited (along with iron compounds) on the lower surface of rock fragments.

Soils of similar character to those just described carry across the crest of narrow outwash remnants. More typically however, the well-drained Cryochrepts are quickly replaced by Histic Pergelic Cryaquepts and occasionally Pergelic Cryaquepts or Pergelic Cryohemists on broad poorly drained crests, (Fig. 66).

Landscape Evolution

It is likely that outwash gravels deposited during the Itkillik I glacial event were partially eroded during the latter part of that event and possibly during the following Itkillik II event as well. Loess deposition may be related to both phases of Itkillik glaciation. Erosional modification of the outwash remnants has probably been sporadic over at least the last 12,000 years particularly after severe forest fires that may have removed the thin surface vegetation and organic horizon of the steep slopes. Fine materials particularly were washed into the lowlands over colluvial slopes. The oldest radiocarbon date obtained in the map area, 7915 ± 180 yr.B.P.,is from fibrous sedge peat at a depth of 140-146 cm in a peat island. Lack of sufficient drill extensions prevented deeper sampling and determination of a date for the beginning of organic matter accumulation. It is reasonable to expect such a date to fall between 10,000 and 15,000 yr.B.P. based upon the known glacial history of the area (Hamilton and Porter, 1975) and basal peat dates from other

Fig. 66 . In contrast to figure 65 the above pictures a broad outwash crest in which poorly drained Histic Pergelic Cryaquepts have developed under Sphagnum - tussock spruce forest.

areas (particularly Atigun and Toolik reports) and (Zoltai and Tarnocai, 1975). The morphology of the core from the peat island suggests the lowland area appeared much as it does today throughout most of the last 8000 years e.g., spruce bog meadow with at times a dominance of tussocks and at other times a dominance of spruce. Charcoal fragments record at least one burn although many others must have occurred of which there was no record or none was found. The increasing amount of Sphagnum especially in the active layer suggests that this particular site (the peat island) may have been elevated with respect to the adjoining fen rather recently as the Sphagnum developed a raised bog and encouraged the build-up of permafrost beneath it. It is not known what caused the development of Sphagnum at this particular site. Often the answer lies in chance, a small area may have escaped burning. Its relative elevation with respect to the surrounding alkaline surface waters permitted the rapid accretion of moss and set the stage for the development of a peat island. Peat islands are probably transitory features depending upon the maintenance of the conditions that brought them into being and some sites may undergo several evolutionary episodes of sedge fens to Sphagnum-forest peat islands and collapse, perhaps due to fire. In the peat core described here there is no evidence for earlier Sphagnum build-up.

Much of the remaining poorly drained area is also dominated by Sphagnum with the soils having histic epipedons. Sporadic fire undoubtedly limits the rapid growth of this moss which is able to create its own moisture environment and depends upon airborne nutrients independent of the mineral soil. It is questionable whether any of the fires are capable of burning off the moss layer and exposing large areas of mineral

soil. However, should this occur it offers an explanation for the relatively uniform thickness of the Histic epipedon of the area's soils. Where mineral soil becomes exposed Eriophorum vaginatum appears to be favored by the availability of nutrients. The considerable microtopographic expression of the tussocks offers suitable environments for other plants e pecially Sphagnum which may eventually encourage a decrease in active layer thickness, a more uniform active layer temperature and moisture regime and cessation of cryoturbation as well as possibly the establishment of Picea mariana. Such a sequence may be portrayed on the colluvial slopes where a mosaic of forest, tussock, frost scars occurs (Fig.59). The relationships between tussocks and Sphagnum has been considered in detail by Brown and Richard (unpublished) and more recently by Chapin et al., 1978).

Ice wedge polygons are uncommon in the map area and are confined to lowland forested fens. It is not known whether these forms are active. Their poor expression and apparently restricted distribution suggests they may be static or relict forms. Present mean annual air temperature for the area 6°C (based upon Bettles, Alaska, Haugen,1980) is just sufficient for ice wedge polygons to form in areas lacking significant amounts of insulating snow cover (Goldthwait, 1976). This probably reflects somewhat more severe climate in the past.

The presence of beaded drainage in some stream valleys is indicative of ground ice probably in the form of ice wedges. Small pits, up to several meters across and a meter deep,are common on the broader poorly drained interfluves. Some are water filled, others are simply wet depressions. They are interpreted as thermokarst features possibly alasses

that have formed in response to melting of relict ground ice. A polygonal pattern if present is now obscured by the thick organic mat and forest.

It is unlikely that patterned ground (ice wedge polygon terrain) is now forming. Permafrost is being maintained and is probably aggrading in areas of rapid peat accumulation. Forest fires may be quite important in limiting the amount of organic matter accumulation within the region as a whole and especially on the narrow crests and flanks of outwash remnants.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soli/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount ($<$ 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophosphate extraction
VC	Very coarse sand 1-2 mm; C coarse sand 1-015 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.
Text Class:	s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam; silty clay loam.

Tramway Bar
Selected Edaphic Characteristics

Soil[5] Profile	Depth (cm)	Horizon	Color[4]	% Organic carbon	Exchangeable Cations Meq/100g Ca	Mg	K	Fe(%) CD	OX	SP	Al(%) CD	OX	SP	pH	Particle Size sands mm(%) VC	C	M	F	VF	TOT	silt/clay µm(%) C	F	C	F	Text Class
113.13	0-2	A1	10YR2/1	22.0										4.1[2]	10	5	3	6	4		27	29	9	7	sil
	2-4	E	7.5YR3/2	5.8	1.1	1.0	0.21	1.30	0.40	0.29	0.19	0.19	0.16	4.2	11	6	3	8	6	33	25	31	9	3	sil
	4-12	B21	7.5YR5/6	0.9				2.60	0.56	0.10	0.40	0.26	0.20	4.9	10	8	3	6	5	33	23	34	9	2	sil
	12-19	B22	10YR4/4		0.5	0.6	0.07	1.70	0.35	0.04	0.31	0.20	0.11	5.6	17	13	6	9	7	51	18	22	7	T	l
	19-30	B23	2.5Y4/4											5.5	12	9	7	14	9	51	18	19	9	3	l
	30-40	B3	2.5Y4/4					1.94	0.48	0.02	0.19	0.09	0.05	5.3	10	9	7	17	12	56	19	17	6	2	sl
	40-74	IIC1	10YR3/3											5.7	43	22	7	8	5	85	7	6	2	T	lcs
112.1	10-3	01																							
	3-0	02	5YR3/2	31.9										3.7[1]											
	0-3	A1	10YR5/2											4.5											
	3-10	Bhir	7.5YR3/4					1.0	0.16	0.20	0.13	0.25	0.22	5.5	7	11	18	44	12	92	5	T	2	T	s
	10-18	B22	7.5YR4/6					1.5	0.17	0.16	0.29	0.21	0.15	6.0	8	11	18	45	11	92	4	2	11	T	s
	18-31	B23	10YR5/8					2.2	0.29	0.43	0.20	0.11	0.13	5.5	13	18	16	33	10	89	4	4	2	T	s
	31-39	Eb	10YR5/2					1.8	0.15	0.02	0.06	0.02	0.02	5.7											
	39-44	B21b	7.5YR4/6											6.1											
	44-66	IIC1	10YR4/3											6.1	26	19	14	25	8	92	5	3	T	T	cs
111.1	8-0	01																							
	0-7	Oe	5YR6/4	48.0										3.7[1]											
	7-12	Oa	5YR3/3	46.0										3.9											
	12-19	A1	5YR2/3	11.4	32.7	5.0	0.35	2.0	0.57	1.09	0.32	0.27	0.32	4.9											
	19-24	B21	10YR3/2		17.0	2.7	0.14	1.8	0.53	0.62	0.22	0.18	0.22	5.7	7	5	2	4	5	23	21	35	14	8	sil
	24-56	IIC1	2.5Y4/2											6.1											
113.5	0-3	01	5YR3/3	44.5										3.6											
	3-5	A1	5YR2/2	28.9										3.8											
	5-13	BC	2.5Y4/2		9.1	2.0	0.27	1.6	0.29	0.22	0.14	0.10	0.19	5.4	3	3	2	6	7	22	18	41	16	4	sil
	13-51	C1	2.5Y4/2		8.5	2.1	0.14	1.9	0.37	0.26	0.14	0.11	0.16	5.7	2	3	2	7	7	22	17	41	14	5	sil
	51+	C2	2.5Y4/2											--											
113.6	0-5	01	10YR2/2	45.3										--											
	5-23	O11	10YR5/4	44.6										--											
	23-36	Oelf	7.5YR4/2											--											
	36-41	IIClf	2.5Y4/2											--											
112.3	0-10	O11	10YR2/2	20.9										6.2[1]											
	10-22	O12	7.5YR3/2	22.3										5.3											
	22-33	IIC1	7.5YR3/2	23.0										5.4											
	33-41	Oa1	10YR2/1	32.8	17.0	1.5	0.20							5.5											

Appendix B

Selected profile descriptions of the soils of the Tramway Bar area. Refer to figures 59 and 61 for topographic setting and Appendix A for edaphic characteristics.

Site: Tramway Bar 111.1

Microrelief: Poorly drained hummocky upland surface. Slope $\ngtr$ 4%.

Vegetation: Few *Eriophorum vaginatum* tussocks; *Picea mariana*; *Vaccinium uliginosum*; *Vaccinium vitis-idaea*; *Betula glandulosa*.

Classification: Pergelic Cryaquept

Remarks: Soil temperature: August 1976. 15 cm $4^{o}C$; 30 cm $0^{o}C$

Depth/Horizon: (cm)

8-0 01	Live moss vegetation. Litter at base of horizon is mixed dead fragments of moss and leaves.
0-8 Oe1	Reddish brown-light reddish brown (5YR 6/4), 4/4) organic fibers; breaks down moderately; weak medium platy; moist, friable and loose; roots coarse and very coarse, few. Some fungal hyphae; few very coarse dead moss fragments. Abrupt, smooth boundary.
8-12 Oe2	Dark reddish brown (5YR 3/3); fine fibrous organic, many charcoal fragments; breaks down easily; moist, friable; at interface of upper boundary is a 1 cm layer of coarse root fragments; few roots. Abrupt, smooth boundary.
12-19 A1	Dark reddish brown (5YR 2/2); organic silt loam; weak medium platy structure; wet, slightly sticky; roots common. Abrupt, smooth boundary.

Depth/Horizon: (cm)	
19-24 B21	Very dark greyish brown (10YR 3/2) silt loam; breaks to weak fine to medium subangular blocky structure; wet, slightly stocky; thixotropic; coarse fragments 10% rounded quartz pebbles; roots common. Abrupt, smooth boundary.
24-56 IIC1	Dark greyish brown (2.5Y 4/2) silty clay loam; moderate fine to medium platy structure; wet; not sticky; roots few; coarse fragments 20% as above; common medium olive brown (2.5Y 4/4) mottles and few medium faint; dark yellowish brown (10YR 3/4) mottles. Permafrost.

Site:	Tramway Bar 112.1
Microrelief:	Base of kame or outwash remnant. Slope 5%.
Vegetation:	Picea glauca; Vaccinium vitis-idaea lichen community, some Ledum palustre
Classification:	Pergelic Cryorthent
Depth/Horizon: (cm)	
10-3 O1	Dark reddish brown (5YR 3/3) litter and live vegetation (lichens); decomposed and partially decomposed roots . Abrupt, smooth boundary.
3-0 O2	Very dark grey (5YR 3/2) organic silt loam; composed mostly of decomposed litter. Abrupt, wavy boundary.
0-3 A1	Grey (10YR 5/2) coarse sand; coarse fragments 5%; structureless, single grain; moist; few roots. Abrupt, wavy boundary.
3-10 B2hir	Dark brown (7.5YR 3/4) coarse sand; coarse fragments 10%; structureless, single grain; moist, few roots. Abrupt, wavy boundary.
10-18 B22	Strong brown (7.5YR 4/6) medium to coarse sand; coarse fragments 20%; structureless, single grain; moist; few roots. Clear, wavy boundary.
18-31 B23	Yellowish brown (10YR 5/8) coarse sand; coarse fragments 30%; structureless, single grain; moist; few roots. Dark brown (7.5YR 3/4) common, medium distinct mottles; few, fine, prominent strong brown-yellowish brown (7.5YR 4/6) - (10YR 5/6) mottles. Smooth, wavy boundary.

31-39 Eb	Greyish brown to dark greyish brown (10YR 5/2) to (10YR 4/2) coarse sand; coarse fragments 40%; few fine roots; also a thin lens very dark greyish brown (7.5YR 3/2) charcoal. Smooth, wavy boundary.
39-44 B21b	Strong brown (7.5YR 4/6) coarse sand; coarse fragments 20%; structureless, single grain; moist; few roots. Smooth, wavy boundary.
44-66 IIC1	Dark brown (10YR 4/3) sandy fine gravel; structureless, single grain; wet, not sticky; roots absent. Profile terminated.

Site:	Tramway Bar 112.3
Microrelief:	Intertussock area, tussock meadow. Slope < 1%.
Vegetation:	Eriophorum vaginatum; Sphagnum; Betula glandulosa
Classification:	Histic Pergelic Cryaquept
Depth/Horizon: (cm)	
8-0	Living vegetation
0-10 Oi1	Very dark brown (10YR 2/2) fibrous organic; very resistant; composed of stems; roots, and Carex sheaths; woody Betula fragments common. Abrupt, smooth boundary.
10-22 Oi2	Dark brown (7.5YR 3/2) fibrous sedge peat; moderately resistant; weak fine platy structure; roots abundant. Abrupt, smooth boundary.
22-33 IIC1	Dark brown (7.5YR 3/2) silt loam; friable; weak fine platy structure; 5% organic fragments; roots abundant. Abrupt, smooth boundary.
33-41 IIIOa1	Black (10YR 2/1) sapric organic; 30% included mineral; leaf and woody stem fragments, frozen.

Site:	Tramway Bar 113.6
Microrelief:	Interstripe area, transitional slope at base of kame. Slope 2%. See 113.5. 24 August 1977
Vegetation:	_Sphagnum_ spp. (thick spongy carpet); _Rubus chamaemorus_/ _Ledum palustre_; _Vaccinium vitis-idaea_; _Vaccinium uliginosum_; few _Eriophorum vaginatum_ tussocks; _Betula_ sp., _Picea mariana_, _Salix_ sp., _Peltigera_ sp.
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
5-0	Living vegetation - _Peltigera_ sp. dominate.
0-5 Oi1	Very dark brown (10YR 2/2) fibrous mat of fine dead roots and moss remains; *fungal hyphae are abundant*. Abrupt, smooth to wavy boundary.
5-23 Oi2	Yellowish brown (10YR 5/4 - 5/6 - moist) fibric _Sphagnum_ moss; roots common especially _Ledum palustre_.
23-36 Oe1f	Brown (7.5YR 4/2 - wet), (7.5YR 3/2 pressed) hemic organic; small charcoal fragments common; live roots abundant at frost contact; much ice. Abrupt, wavy boundary.
36-41+ IIC1f	Dary greyish brown (2.5Y 4/2) micaceous fine sandy loam till; ~ 5% fine gravel.

Site:	Tramway Bar 113.5
Microrelief:	Stripe area, transitional slope at base of kame. Discontinuous soil islands approximately 2 m wide.
Vegetation:	_Picea mariana_ older trees ~ 100 years, younger trees (≈ 1 m) ~ 30 years. _Cladonia_ spp., _Salix_ sp., _Ledum palustre_, _Vaccinium vitis-idaea_; _V. uliginosum_, _Betula glandulosa_
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Living vegetation
0-3 O1	Dark reddish brown (5YR 3/3) fibrous mat of fine dead roots, moss and few sedge fragments; brown (10YR 4/3) fine sand (~ 50%) fungal hyphae and fine roots common. Abrupt, wavy boundary.
3-5 A1	Dark reddish brown (5YR 2.5/2) fibrous fine roots and moss; little mineral. Abrupt, wavy boundary.
5-13 BC	Dark greyish brown (2.5Y 4/2) micaceous silt loam; few sedge fragments, few roots, structureless; fine to medium granular or aggregate structure at upper boundary. Abrupt, smooth boundary.
13-51+ C1	Dark greyish brown (2.5Y 4/2) micaceous silt loam; structureless - moderate medium (.5-1cm) ice segregation partings; moderate fine dark grey (10YR 4/1) and prominent moderate fine yellowish

brown (10YR 5/8) mottles; rounded fine gravel (~ 5%) in upper 20 cm; finer gravel common below; thixotropic; mottling continues with depth to 76 cm; colors becoming more prominent and pattern coarser. Frozen at 76 cm.

Appendix C

Area (% of Total) summary for all soil-landform map units appearing in Fig.59 .

Map Unit	% of Area
1,2,1	1.3
1,2,2	1.4
1,2,3	.3
12,2,1	1.6
12,2,2	.3
1-2,2,2	1.2
13,3,2	.4
1-3,3,3	.9
12,4,1	1.3
12,4,2	2.9
12,4,3	.2
1-2,4,3	.8
1,4,2	1.3
1,7,2	.7
1,8,1	1.2
2-1,4,1	1.4
2-1,4,2	3.0
2-1,4,3	5.2
21,5,1	.1
2-1,5,1	16.1
2-1,5,2	2.9
2-1,5,3	.4
2,2,1	1.7
2-3,3,2	.3
2-3,4,3	1.5
2-4,4,1	.1
2-4,5,2	.5
2-4,6,1	2.4
2-4,6,1	.6
2,4,6,1	.2
2,4,2	2.4
2,4,3	1.6
2,4,4,	.7
2,5,1	.6
2,5,2	.5
2,5,3	.3
27,6,1	1.3
2,7,1	5.7
3,1,1	1.9
3,1,2	.7
3,1,3	.3
31,2,2	.3
32,1,2	.2
32,3,3	.2
3,2,1	.4
3-2,1,2	2.0
3-2,1,3	.2
3,3,2	1.7
3,3,3	1.6
3,3,4	.5
3,3,5	3.6
3,5,3	.4
3,5,5	.1
4-2,2,3	1.0
4-2,4,1	.6
4-2,4,2	.2
4-2,4,3	.6
4,4,3	.1
45,P,1(P)	.9
4,6,1	2.6
4,6,2	4.2
4,6,3	.2
4,7,1	1.2
5,6,1	2.7
5,P,1	.3
7,P,1	.1
L	2.5

Finger Mountain Site

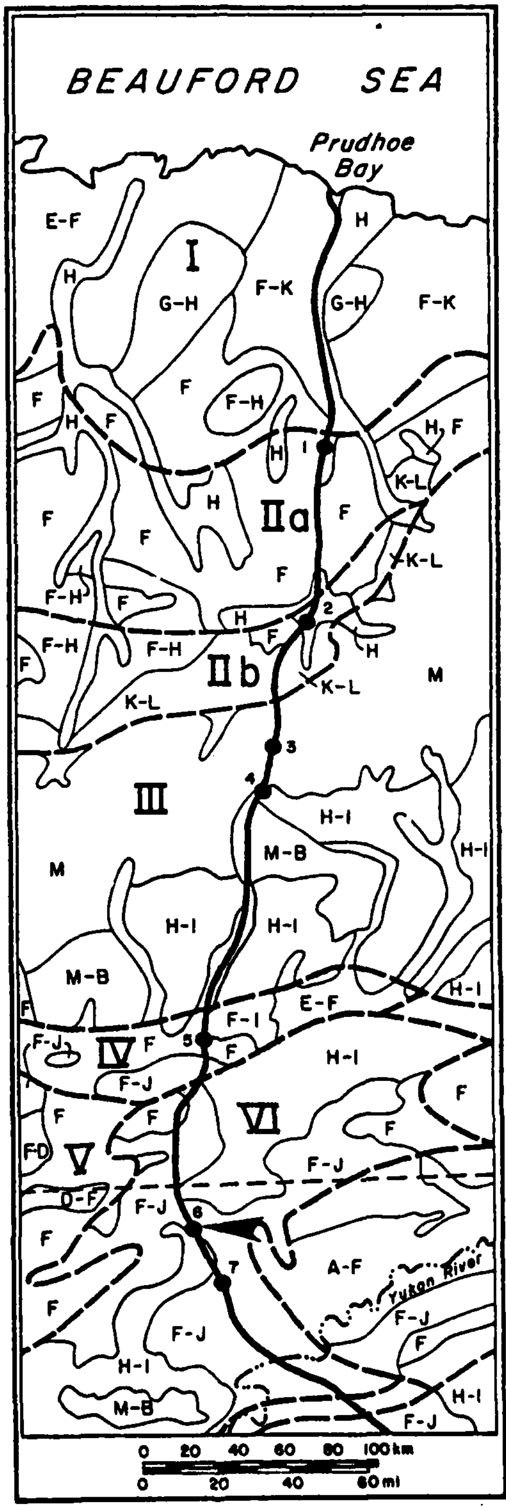


Fig. 65. Location of the Finger Mountain site (6) with respect to regional physiographic and soils boundaries.

Physical Geography

Geology

The Finger Mountain site lies within the Kokrine-Hodzana Highlands section of the Intermontane Plateaus defined by Wahrhaftig (1965). It is some 61 km (38 mi.) north of the Yukon River road crossing in the headwaters of the west fork of the Dall River. The area is south of the glacial boundary and is underlain by weathered granitic rocks of probable upper Cretaceous age (see Brosgé *et al.*, 1973 and Kachadoorian, 1971) these intrude lower Paleozoic and/or Precambrian metasedimentary rocks that include schists, phyllites and greenstones (Beikman, 1978). Weathering, especially of the prophyritic granite, extends to several meters and has produced an accumulation of grus. More resistant lithologies stand as tors (see Fig. 2) particularly on divides where bedrock is close beneath the polygonally patterned felsenmeer. The presence of tors attests to a protracted period of weathering and the absence of glacial ice. The tors are jointed and a bedrock joint pattern nearly N-S/E-W is outlined by the thin mantle of coarse boulders that compose the felsenmeer (see Fig. 68).

Topography and surface forms

Although summit elevations within the general area reach from 750 m to greater than 1000 m, those of Precambrian metasediments in the map area are very close to 625 m and local relief is on the order of 125 m. Divides are relatively broad (1 to 2 km), gently rounded and dotted with tors, most commonly at intersections and terminations. Felsenmeer occurs on the divides and well down the gentle (> 5%) slopes leading away from them.

Fig.66. Tor at a divide terminus on Finger Mountain. A vegetation covered polygonally patterned felsenmeer surrounds the tor. Low vegetation in autumn color is mostly willow (Betula glandulosa) Lichens appear white. Flagged and layered trees (Picea mariana) appear in left upper foreground and right center respectively. Still green alder (Alnus viridis) complete the prominent vegetation.

These materials may be arranged into areas of large, 8 to 10 m diameter boulder bordered polygons some with small centers of fine mineral soil and generally free of vegetation except for lichens, others have large mineral soil centers and considerable vegetation (Fig.67). In some areas the patterned felsenmeer appears buried beneath vegetation (Fig.66). As slope angle increases to 8 to 10%, shallow drainages and poorly developed stripes occur. The drainages are generally wet and in many cases contain solifluction features (hummocks and lobes). The wetter sites together with solifluction microtopography (commonly $<$ 0.5 m) become extensive lower on the slopes as the major drainageways are approached. Also common to the slopes, especially near drainages are areas of lichen covered boulders often surrounded or in some cases overgrown by thickets of alder or willow. A polygonal pattern is common to such areas but fine textured mineral soil centers are very small (a meter or less) or lacking. Relief may be a meter or more and many of the boulders or slabs are loose or "rocking". Water can sometimes be heard running beneath such boxworks. The major drainage channels themselves are often narrow and boulder filled. A few are broad enough to have marshy flood plains.

The southern third of the map area is characterized by a long, uniform, low angle (5%) slope on which boulders are absent. A progression of turf banked terraces, stone stripes, low solifluction lobes and extensive areas of tussocks and frost scars follow downslope and reflect the finer textured lithology of the rock in this area.

No lakes or ponds occur in the map area although they are abundant in the broad lowland just 5 km north that constitutes the headwaters of the Kanute River.

Fig.67. Large apparently stable block bordered polygons typical of the felsenmeer surface as slope angle begins to increase. Similar size features are almost completely submerged in vegetation further up slope (Fig.66). Mineral soil centers are large in comparison to those in polygons of boulder islands further down slope. Green vegetation is alder.

Permafrost

Although the broader area surrounding Finger Mountain is included within the general zone of discontinuous permafrost, most excavations within the map area encountered frost within a meter of the surface. On the felsenmeer slopes permafrost was found between 40 and 70 cm: the depth of the active layer depending on the presence and thickness of sphagnum peat. Permafrost on the tussock-frost scar slope at the south end of the map area ranged between 30 and 70 cm (average of 47 cm) with the deeper values being from frost scars. In the well-drained gravelly soils permafrost exceeded 80 cm and may reach more than 2 m. A late August temperature of $8^{o}C$ at 80 cm was recorded in one such site.

Throughout the map area the Trans-Alaska pipe line is fully buried. This indicates that there is little massive ground ice at least at the higher elevations on south and southeast facing slopes. The apparent lack of massive ground ice (i.e., primarily wedge shaped bodies of ice) raises climatic questions about the origin and current state of activity of the large block bordered polygons so common on these uplands. This will be dealt with when the evolution of the landscape is discussed. Massive ground ice is encountered on the lower parts of the slopes and in the narrow flood plains of some of the larger streams.

Vegetation

Webber *et al*. (1979) mapped a portion of the Finger Mountain area immediately to the north of the soils map area. They describe the area as approximately at treeline and containing forested areas, a subalpine band of tree islands and a dry upland with widely and evenly spaced

alder shrubs. The alder (Alnus viridis) uplands are not as well developed in the soils map area as elsewhere. The long regular solifluction slope (Fig. 68) has in addition to alder, Betula glandulosa, Ledum palustre and Carex bigelowii as dominant vascular species. Lichens include Cetraria, cucullata and Cladonia rangiferina. Isolated small (stunted?) flagged and layered individuals of Picea mariana together with broken and charred snags are found below midslope. Shrub thickets mainly of B. glandulosa occur in localized, wetter areas, A. viridis and small isolated trees (Picea mariana are common associates. Sphagnum spp. is a common understory species.

Down slope a narrow, transitional vegetation band dominated by B. glandulosa, tussocks of Eriophorum vaginatum and P. mariana separates a dense well developed forest of P. mariana from the nonforested higher slopes.

The relatively dry uplands of patterned felsenmeer (Figs. 66 and 68) have vegetation composed of small trees. Betula papyrifera, dwarf shrubs (Ledum palustre, B. glandulosa) together with the grass Hierchloe alpina. Sphagnum spp. and a variety of mosses form the understory. The exposed rock surfaces are densely covered by lichens. Scattered, flagged and layered individuals of P. mariana (Fig. 66) are common. Down slope occur large and small boulder (tree) islands with P. mariana, B. papyrifera and A. viridis. Between the islands are meadows and/or solifluction slopes composed of Carex bigelowii, B. glandulosa and Sphagnum spp.

Granitic areas on which the soils are composed of gravelly sands support open stands of P. glauca and an understory composed of Cladonia (cf. alpestris) with B. papyrifera, L. palustre, Empetrum eamesii and Vaccinium vitis-idaea as common associates.

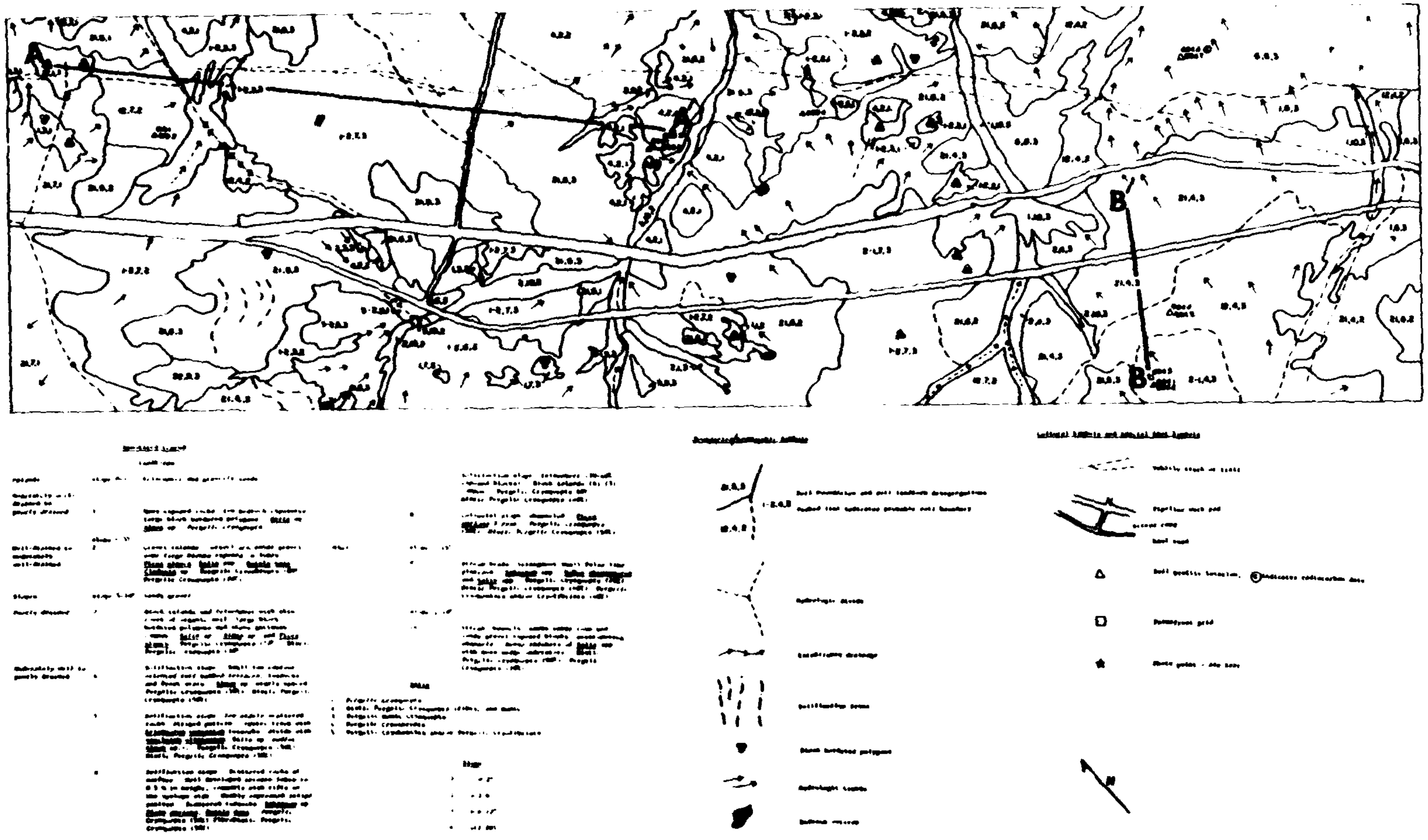
Small streams are boulder floored. Those with broader channels have dense willow thickets and an understory of Sphagnum spp. and sedges.

Soils

The Finger Mountain area contains a diversity of soils ranging from extremely acid highly decomposed organic soils to strongly and medium acid well-drained base poor mineral soils. The well-drained soils occupy areas of deeply weathered Cretaceous granites and/or colluvial deposits in which granitic materials are a significant part (Fig.68). In a fashion similar to the Tramway Bar site to the north and No Name Creek to the south (Fig. 1) the well-drained sites at Finger Mountain are easily distinguished by the presence of open stands of white spruce and paper birch and a white ground cover composed of lichens. Within short lateral distances textures range from coarse sandy loams to loams. A thin bleached, elluvial, E horizon, is present in nearly all profiles immediately below the organic rich A1 horizon. Below the E horizon are a series of B horizons that extend to depths of up to 50 cm (profiles 606.3 and 606.20, Fig. 69) Appendices A and B). The yellowish brown color of these horizons is indicative of the strong oxidizing conditions that prevail. Some of the ferric iron perhaps a significant portion of it, and aluminum as well, have been removed from or through the E horizon and redeposited in the less acid B horizons. Weathering of iron bearing minerals within the B horizons has probably contributed as well to their content of free iron oxide. The amount of free iron oxide in the soil matrix decreases with depth in the profile (Appendix A). Iron oxide extracted by Na-pyrophosphate has been moved into the B horizons in suspension, probably as an

SOIL LANDFORM MAP

Mile 38.25 - Mile 42.25 TAPS Haul Road



MAP SYMBOLS

5,7,2

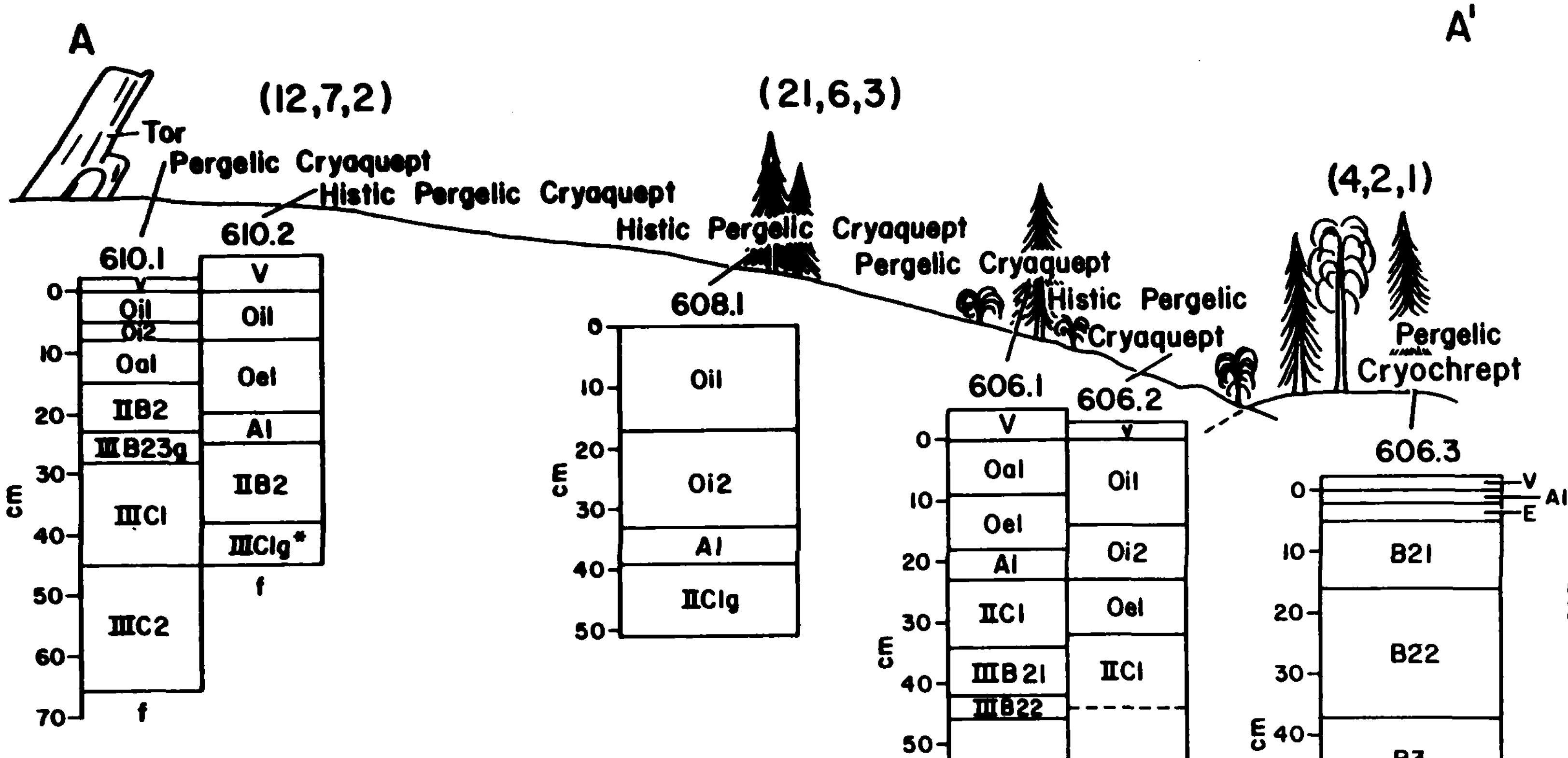
(Soil(s)), (Landform), (Slope)

Fig-68

organo-metalic chelate. Downward movement of water containing both dissolved and suspended materials is demonstrated by the presence of silt and clay coatings on the upper surfaces of the larger gravel and/or cobble fragments. However, a significant increase in clay within the B horizon is demonstratable only in profile 606.20. These deposited fine sediments appear preferentially enriched, compared to the soil matrix, in dithianite-citrate extractable free iron oxide and to a much less degree in pyrophosphate extractable free iron oxide. Thin patchy coatings of iron oxide and/or iron hydroxide are found on the under surface of many of the larger rocks and further attest to movement in solution. Aluminum oxide appears to be rather evenly distributed within the soil profile, matrix or entrained sediment, regardless of its state of crystallinity.

Although cation exchange capacity and the quantity of exchangeable cations was not measured in the well-drained soils, both can be assumed to be low, especially in profile 606.3 (Appendix A) primarily because of the low clay content.

The well-drained soils display some of the characteristics of podzolic soils or subarctic brown forest soils (DeMent, 1962) and prior to 1972 would probably have been included within this group. The new and more rigorous criteria of Soil Taxonomy (Soil Survey Staff, 1975) requires the majority of the well-drained soils of Finger Mountain to be included within the Order Inceptisols as Pergelic Cryochrepts (see discussion on pgs. 235-348).



Soils representative of section A–A' (Fig.68).

Section length approximately 1.5 km.

Map units shown above taxonomic names.

For detailed descriptions of most profiles see Appendix A.

f = frozen   * = charcoal fragments   V = vegetation

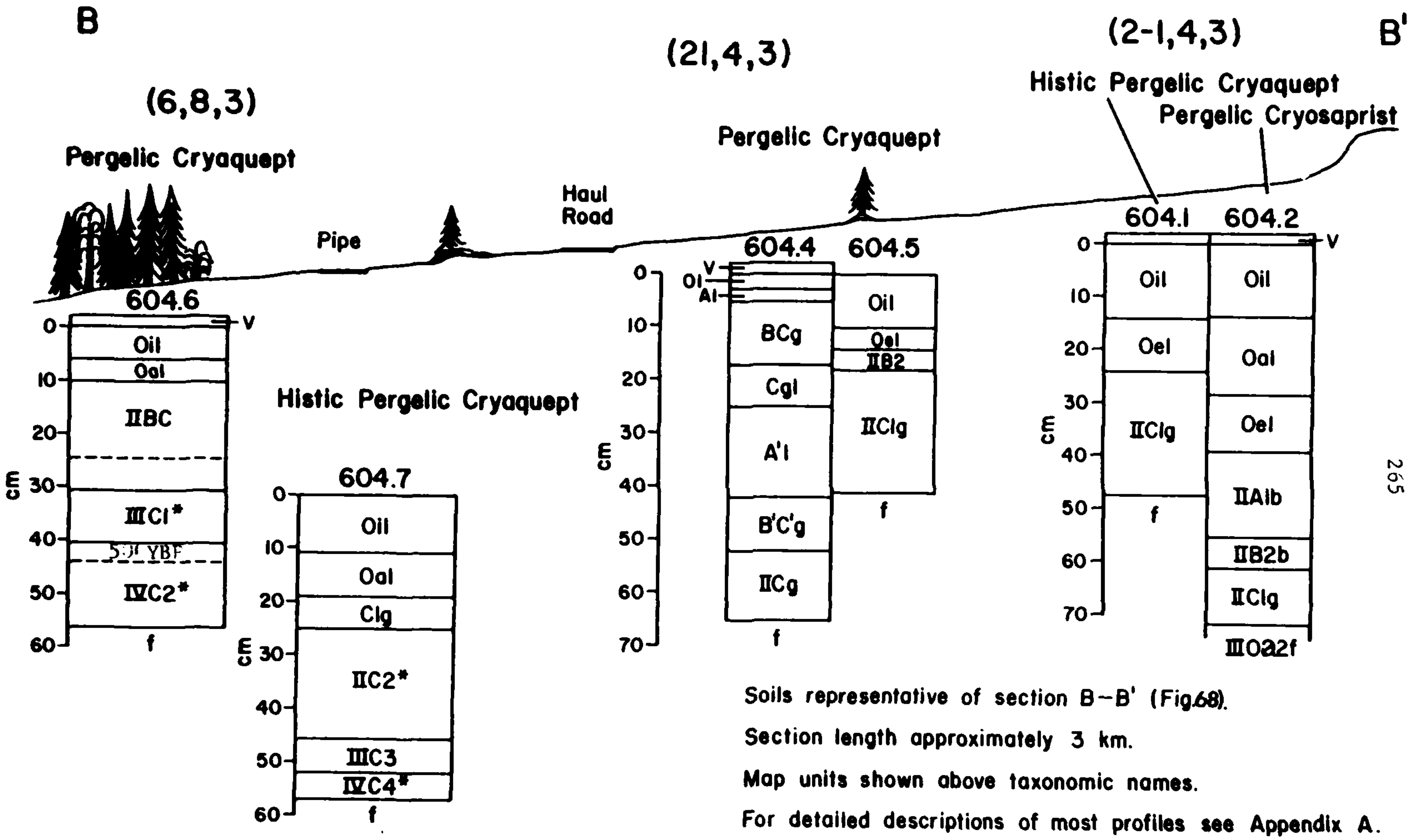
Fig.69

Wet Inceptisols comprise the bulk of the Finger Mountain map area (Fig.68). Many of these soils have histic epipedons and are designated Histic Pergelic Cryaquepts. They commonly form complexes or associations with Pergelic Cryaquepts. In a few areas the organic surface horizons may reach sufficient thickness for the soil to be classified as an organic soil or Histosol (Fig.70, profile 604.2). This is common on slopes where solifluction creates depressions and hummocks.

In all cases the mineral horizons are of loamy or coarser texture. A, B or BC horizon can be differentiated below the organic upper horizons. The B horizons are defined principally on the presence of oxidation colors (color B's) and may not strictly meet all the criteria established for a Cambic horizon (Soil Survey Staff, 1975).

Chemical data from similar soils in other areas in northern Alaska indicate significant amounts of free iron occur in these horizons, in many cases in amounts greater than in the B horizons of the well-drained soils. Because of the very poor drainage in the wet Inceptisols iron, in the reduced state, tends to accumulate as it is released through organic decomposition.

As the name implies the Aquepts are saturated with water for some time during the thaw period. In the case of these relatively coarse textured sloping soils this is probably most common for short periods in the upper horizons in the region adjacent to the thawing front, and for longer periods as the rate of thaw slows in the deeper horizons. The alternating oxidizing-reducing conditions within the profile are recognizable as mottles. Only rarely do saturated and anerobic conditions



Soils representative of section B−B' (Fig.68).

Section length approximately 3 km.

Map units shown above taxonomic names.

For detailed descriptions of most profiles see Appendix A.

f = frozen   * = charcoal fragments   V = vegetation

Fig. 70

persist such that no soluable ferrous iron becomes oxidized. Where this does occur it is deep in the profile near the mean permafrost table or in soils in wet depressions where circulating water does not occur.

A characteristic of the Cryaquepts soils of Finger Mountain and elsewhere in arctic Alaska is the presence of buried highly decomposed organic materials either in distinct horizons or as interrupted inclusions and smears. This feature is commonly attributed to cryoturbic (frost churning) activity especially associated with solifluction and/or with the presence of frost scars. The precise mechanisms by which this occurs are little understood.

Charcoal fragments are common in the Cryaquept soils. Individual pieces are small, suggestive of woody stems e.g., *Ledum palustre* and although they may occur in any mineral horizon most appear associated with the C horizon. Fragments are too small and widely dispersed to provide reliable radiocarbon dates.

Although Histosols have been noted in the area they are a minor component of the soil landscape. Where they do occur the thick organic horizons are the product either of over-thickening resulting from solifluction movement or the presence of rapidly accumulating *Sphagnum* moss. The rapidity with which *Sphagnum* may accumulate has required special thickness provisions within soil taxonomy hense organic horizons 40 cm thick when composed of sedge or non-*Sphagnum* mosses qualify as organic soils. When *Sphagnum* is involved 60 cm of organic is required. This is not achieved in the Finger Mountain area.

Landscape Evolution

There is no evidence that the Finger Mountain site was glaciated during the last major glacial episode i.e., the Wisconsinian even though in this area, snow line was reduced to approximately 1000 m (Péwé, 1975) the Finger Mountain upland was some 300 meters lower. Some of the higher adjacent areas may well have had permanent snow banks. Mean summer air temperatures were probably 2 to 4°C colder than present i.e, about -2 to -4°C during the Wisconsinian period. Thus the area was subjected to a rigorous periglacial climate. The extensive block fields together with their sorted large diameter polygons, t o r s and deeply frost scattered bedrock were probably produced during such a period. It should be pointed out that climates of greater severity than present and similar to or more severe than the Wisconsinian affected the Finger Mountain area throughout the Pleistocene and perhaps contributed to the present landscape features. Today these features may be considered as static forms having completed their development. They should not, however, be preceived as fossil forms. Isolated flagged spruce and krummholz found on these upland surfaces attest to an alpine climate that is at least sufficient to maintain the features. The poorly differentiated soils associated with the upland surfaces result from a combination of restricted drainage due to permafrost and site instability resulting from frost heaving.

Long uniform slopes have been produced by solifluction and creep in wet sandy loams, the weathering products of the underlying schists and greenstones. Frost scars and discontinuous soil stripes are common to these slopes. It is tempting to speculate that the seemingly even spacing of alder on such slopes (as well as the felsenmeer surfaces)

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SOIL-LANDSCAPE RELATIONS AT SELECTED SITES ALONG ENVIRONMENTAL --ETC(U)
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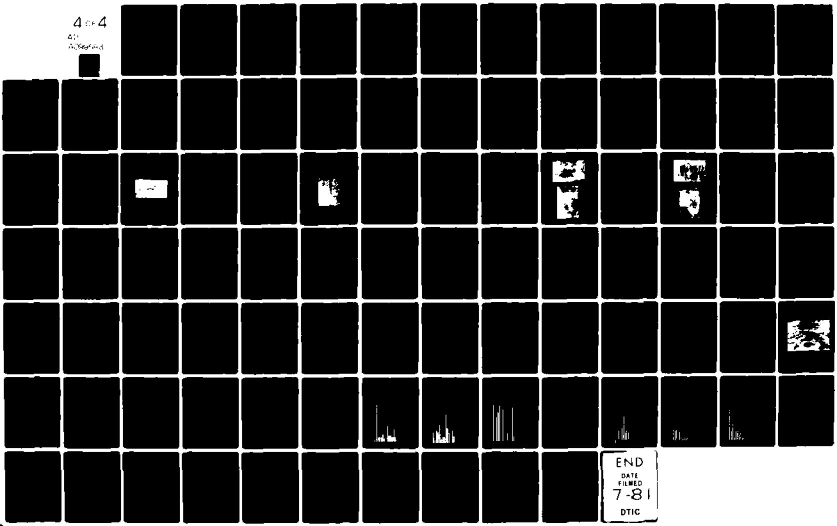
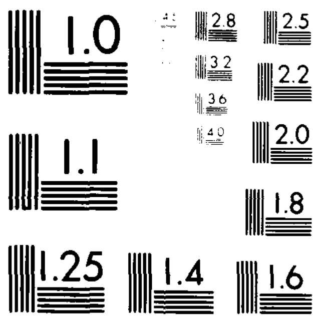
4 OF 4





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

There is no indication from the soils (or the present vegetation) that forest has covered these slopes in any very recent time. Although charcoal fragments are present throughout the mineral soil horizons it appears to have been derived from shrubs not forest trees.

On the lower parts of the slopes, below the alpine and sub-alpine zones are dense stands of black spruce interspersed with paper birch. Although some solifluction forms can be found they are few. Some forested slopes such as the one in which soil profiles 604.6 and 7, Fig. 70, were described have a series of nearly parallel waterways and finer textured soils than upslope. A radiocarbon date of 525 ± 120 years B.P. (GX 5110) obtained from a buried surface (matted leaves) profile 604.6, suggest an influx of sediments, possibly washed from upslope. This may have resulted from fire burning away much of the tundra vegetation and exposing soils to water erosion. A similar, more recent buried leaf layer occurs in the same profile. The incorporation of charcoal fragments in the Cryaquept soils in the alpine zone may have occurred in response to increased cryoturbation subsequent to fires. Re-establishment of vegetation and aggredation of the permafrost (the present situation) provides periods of relative landscape stability.

Appendix A

Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soil/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount (< 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophospate extraction
VC	Very coarse sand 1-2 mm; C coarse sand 1-0.5 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay < 0.2 μm.

Text Class: s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam; silty clay loam.

Finger Mountain
Selected Edaphic Characteristics

Soil[5] Profile	Depth (cm)	Horizon	Color[4]	Organic carbon	Exchangeable Cations Meq/100g Ca	Mg	K	Fe(%) CD	OX	SP	Al(%) CD	OX	SP	pH	VC	C	M	F	VF	TOT	C	F	C	F	Text Class
606.1	0-9	Oe	5YR2/1	43.9										4.6											
	9-18	Oe	10YR3/2-3/1	42.1										4.2											
	18-23	A1	10YR3/2											4.3											
	23-34	IIC1	5Y4/2		2.3	0.7	0.09							4.8	15	11	5	8	4	42	14	31	9	3	l
	34-42	IIIB21	10YR3/3		1.1	0.3	0.07							4.3	22	16	8	12	6	63	12	18	5	2	csl
	42-46	IIIB22	10YR3/4-3/6		3.2	T	0.08							4.4	22	17	9	18	10	75	9	10	5	1	csl
	46-69	IVC1	5Y4/2											4.8											
606.2	0-14	O11	5Y5/4	42.5										4.3											
	14-23	O12	5Y3/2	39.5										4.4											
	23-32	Oe1	5Y2/2	42.0										4.2											
	32-44	IIC1	2.5Y4/2		2.6	0.7	0.17							4.4	15	11	5	7	3	41	13	32	10	3	l
608.0	0-17	O11	10YR4/6																						
	17-25	O12	10YR4/4																						
	25-33	Oa1	10YR2/2	39.7										5.2[2]											
	33-39	Oa2	10YR2/1	31.0	2.0	0.8	0.06							5.1											
	39-51	IIC1	10YR4/1											5.4	20	16	7	9	4	56	16	17	8	4	csl
606.3	0-2	A1	7.5YRN21											3.9[1]											
	2-5	A2(E)	7.5YR7/2											4.4											
	5-16	B21	7.5YR5/6		0.4	T	0.06	1.31	0.15	0.18	0.26	0.20	0.24	4.7	22	20	9	14	6	71	5	15	6	2	csl
	16-37	B22	10YR5/6		0.4	T	0.08	0.86	0.08	0.09				5.2	27	22	9	12	4	74	7	13	6	T	csl
	37-50	B23	10YR5/4				0.58	0.58 0.11[3]	0.06 0.06	0.06 0.45	0.19 0.36	0.21 0.51	0.15 0.28	5.5	24	22	8	13	6	74	8	15	4	T	sl
	50-75	C1	10YR5/4					0.84 0.07	0.09 0.27	0.10 0.05	0.20 0.19	0.17 0.27	0.19 0.16	5.3	18	18	8	12	5	61	11	21	6	T	sl
	75+	C2	10YR5/4					0.56 0.07	0.05 0.40	0.06 0.05	0.12 0.22	0.12 0.34	0.12 0.18	5.7	22	21	11	17	8	79	7	11	3	T	lcs
606.20	0-2	A1	10YR2/1	27.2										4.2[2]											
	2-4	A2(E)	10YR5/4	10.6										4.2	24	16	8	9	3	60	14	16	7	4	csl
	4-8	B21ir	10YR4/4	1.7										4.3	14	15	7	9	4	49	15	19	9	8	l
	8-17	B22	10YR5/6											5.1	9	9	4	6	3	31	19	27	12	11	l
	17-24	B21	7.5YR4/4											5.0	10	9	4	6	5	34	24	30	11	3	sil
	24-26	C1	10YR4/4											5.2	12	11	5	8	5	41	22	27	8	1	l
	46-69	C2	10YR4/3											5.0	13	12	6	9	5	46	20	26	7	T	l
604.1	0-14	Oi	5YR4/4	43.8										3.8[1]											
	14-24	Oe	2.5YR3/2	41.8										3.9											
	24-47	IIC1	5Y4/1											5.3											
604.2	0-13	O11	5YR3/3	46.3										3.3											
	13-28	Oe1	5YR2/1	44.5										3.8											
	28-39	Oe1	7.5YR3/2	33.3										3.8											
	39-56	IIC1	7.5YR3/2	16.4										4.0											

Appendix B

Selected profile descriptions of the soils of the No Name Creek area. Refer to Fig.68 and Appendix A for topographic setting and edaphic characteristics.

Site:	Finger Mountain #604.1
	Old inactive frost scar; back of turf lobe on riser or solifluction lobe.
Slope:	8%
Vegetation:	<u>Betula glandulosa</u>; <u>Ledum palustre</u>; lichens; scattered <u>Alnus viridis</u>, <u>Vaccinium Vitas-idaea</u>
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
2.5-0	Live vegetation mostly <u>Cladonia</u> sp.
0-14 Oi1	Reddish brown (5YR 4/4) pressed; reddish brown (5YR 3/4) wet; fibric organic; breaks down moderately; weak medium platy structure; roots common. Abrupt, smooth boundary.
14-24 Oe1	Very dark greyish brown (2.5YR 3/2) wet; dark reddish brown (5YR 2.5/2) pressed; hemic; organic breaks down easily; moderate medium platy structure; many roots. Abrupt, smooth boundary.
24-47 IIC1g	Dark grey (5Y 4/1) micaceous very fine sandy loam; thixotropic; slightly sticky; common, medium distinct olive brown (2.5Y 4/4) mottles; common weak prominent dark yellowish brown (10YR 4/6) mottles around roots; roots common. Frost 1 September 1976.

Site:	Finger Mountain #604.2
	Riser portion of turf banked terrace. Approximately 2m from 604.1.
Slope:	10%
Vegetation:	Scattered _Carex_ sp., _Ledum palustre_; _Vaccinium uliginosum_; _Citraria_ sp.; _Cuculata_ sp., _Betula_ sp., few spruce (_Picea mariana_) and _Alnus viridis_
Classification:	Pergelic Cryosaprist
Depth/Horizon (cm)	
5-0	Vegetation
0-13 Oil	Dark reddish brown (5YR 3/3) fibric organic (sedge); roots abundant. Abrupt, smooth boundary.
13-29 Oal	Black (5YR 2/1) sapric organic; sedge fragments common; black (7.5YR N2/) granular iron humates in lower 2 cm; roots abundant. Abrupt, smooth boundary.
29-39 Oel	Dark brown (7.5YR 3/2) hemic organic (sedge) weak, fine platy structure; few iron humates in lower 2 cm; roots common; scattered charcoal fragments; small gravel fragments. Abrupt, wavy boundary.
39-55 IIC1	Dark brown (7.5YR 3/2) fine sandy loam; friable; sedge fragments common; weak, fine platy structure; quartz granules; few charcoal fragments. Abrupt, smooth boundary.

55-61 IIC2	Dark brown (10YR3/3) fine sandy loam; friable; breaks to moderate subangular blocky structure; roots common; iron humates in upper 2 cm. Abrupt, wavy boundary.
61-71 IIIC3g	Olive grey (5Y4/2) micaceous loamy fine sand; moderate medium platy structure; common, weak, medium dark brown (10YR3/2) mottles; roots common. Abrupt, wavy boundary.
71-74 IVA1bf	Dark reddish brown (5YR3/2) fibric organic (sedge); strong, fine platy structure.

Site:	Finger Mountain #604.4
	Frost scar.
Slope:	10%
Vegetation:	Scattered <u>Carex</u> sp. and moss.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Live vegetation
0-3 O1	Dark reddish brown (2.5YR 2.5/4) fibric moss peat; many fine, dead roots; loose. Abrupt smooth boundary.
3-5 O2	Dark reddish brown (5YR 3/2) sapric organic silt loam. Abrupt, smooth boundary.
5-17 BCg	Dark greyish brown-olive brown and olive grey (2.5Y 4/2-4/4) loamy fine sand; few granules; olive grey (5Y 4/2) wet not sticky; thixotropic; strong brown (7.5YR 4/6) common coarse distinct; mottles; fine roots abundant; sedge fragments common. Abrupt, smooth boundary.
17-25 C1g	Dark brown (10YR 4/3) fine sandy loam; friable; weak medium subangular blocky to granular structure; slightly thixotropic; roots common. Abrupt, smooth boundary.
25-42 A1b	Very dark greyish brown (10YR 3/2) mixed with very dark brown (10YR 2/2) organic silt loam; occasional granules and rock fragments. Abrupt, wavy boundary.

Depth/Horizon (cm)	
42-52 BC'g	Dark brown (10YR 4/3) fine sandy loam; medium weak platy structure; 5-10% granules; dark yellowish brown (10YR 4/6) many prominent fine to medium mottles; dark greyish brown (10YR 4/2) fine prominent mottles; roots common to few. Abrupt, wavy boundary.
52-50 IIClg	Light olive brown (2.5Y 5/4) fine sand; common fine distinct dark grey (10YR 4/1) mottles; yellowish brown (10YR 5/6-5/8) common medium prominent mottles; roots common. Frost at 72 cm. 31 August 1977.

Site:	Finger Mountain #604.5
	Long uniform slope with frost scars, turf banked terraces and split pools - terrace element.
Slope:	10%
Vegetation:	Betula sp.; Ledum palustre; Vaccinium uliginosum; moss
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-10 Oil	Dusky red (2.5YR 3/2) fibrous sedge peat; loose; abundant roots. Abrupt, wavy boundary.
10-14	Very dusky red (2.5YR 2.5/2) hemic sedge peat; abundant roots and stems. Abrupt, smooth boundary.
14-18 B2	Dark brown (7.5YR 3/2) fine sandy loam; friable; weak fine platy structure; few quartz granules; roots common. Abrupt, wavy boundary.
18-41 Clg	Dark greyish brown (2.5Y 4/2) micaceous fine sandy loam; weak fine platy structure; thixotropic near permafrost; common medium dark brown (7.5YR 4/4); dark greyish brown (10YR 4/2) and yellowish brown (10YR 5/6) mottles; few large quartz granules. Frost 8/31/77.

Site:	Finger Mountain #604.6
	Uniform slope with widely spaced parallel drainage
Slope:	9%
Vegetation:	Closed black spruce forest
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Living vegetation
0-6 Oi1	Dark reddish brown (5YR 3/2) fibrous <u>Sphagnum</u> moss and fine roots; fungal hyphae common; roots abundant. Abrupt, smooth boundary.
6-10 Oa1	Dark reddish brown (5YR 2.5/2) sapric organic; moist, friable; stem fragments common; roots common. Abrupt, smooth boundary.
10-31 IIBC	Dark brown (7.5YR 3/2) micaceous silt loam; moist; friable; wood charcoal fragments abundant; thin compressed forest litter zone at 25 cm composed of leaves and stem fragments (500 Y.B.P.); breaks to weak medium subangular blocky structure. Abrupt, wavy boundary.
31-41 IIIC1	Dark brown (7.5YR 3/2) loamy very fine sand; moist; friable; breaks to a weak very coarse subangular blocky structure; charcoal fragments common; plant fragments common. Abrupt, wavy boundary.

Finger Mountain #604.6

Depth/Horizon (cm)	
41-56 IVC2	Very dark greyish brown (10YR 3/2) very fine sandy loam; occasional charcoal fragments, few organic fragments; common coarse prominent very dark greyish brown (2.5Y 3/2) mottles. Compressed forest litter at 44 cm. Frost. 31 August 1977.

Site:	Finger Mountain #604.7
	Approximately 3 m from 604.6
Slope:	9%
Vegetation:	*Sphagnum* sp.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
0-11 Oi1	Light yellowish brown (10YR 6/4) *Sphagnum* peat; loose; few roots. Abrupt, smooth boundary.
11-19 Oa1	Dark reddish brown (5YR 2.5/2) sapric organic; moist; friable; stem fragments common; occasional coarse sand grains; roots common. Abrupt, wavy boundary.
19-25 C1g	Very dark brown (10YR 2/2) silt loam; dark reddish brown (5YR 3/3) few coarse prominent mottles; somewhat friable; breaks to weak coarse subangular blocky structure; fine roots abundant. Abrupt, wavy boundary.
25-46 IIC2	Very dark greyish brown (10YR 3/2) and dark reddish brown (5YR 3/2) very fine sandy loam; moderately friable; inclusions of charcoal fragments; black (7.5YR N2/)and iron humates; few fine roots. Abrupt, wavy boundary.
46-52 IIIC3	Dark brown (7.5YR 3/4) coarse sand; moist; friable; roots absent. Abrupt, wavy boundary.
52-57 IVC4	Dark brown (7.5YR 3/2) very fine sandy loam; organic fragments common; charcoal fragments common; slightly thixotropic; occasional pebbles. Frost 31 August 1977.

Site:	Finger Mountain #606.1
	Solifluction lobes and "pull away" fissures.
Slope:	2%
Vegetation:	<u>Carex</u> sp.; <u>Sphagnum</u> sp.
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
5-0	Live vegetation; <u>Cladonia</u>; <u>Carex</u>; <u>Sphagnum</u>
0-9 Oa1	Dark reddish brown (5YR 2.5/1) sapric organic; roots common; sedge fragments common; most coarse roots in upper 5 cm. Abrupt, smooth boundary.
9-18 Oe1	Very dark grey (10YR 3/2-3/1) to very dark grey brown hemic sedge peat; weak fine platy; few roots. Abrupt, wavy boundary.
18-23 A1	Very dark greyish brown (10YR 3/2) organic gravelly fine sandy loam; moist; friable; sedge fragments common; few roots. Abrupt, wavy boundary.
23-34 IIC1	Dark reddish grey (5Y 4/2) micaeous; fine gravelly loamy fine sand; thixotropic; roots common. Abrupt, smooth boundary.
34-42 IIIB21	Dark brown (10YR 3/3) gravelly coarse sand; gravel fragments have silt coats on top and clean lower side; mica flakes abundant; thixotropic; few roots. Abrupt, smooth boundary.
42-46 IIIB22	Dark yellowish brown (10YR 3/6-3-4) gravelly medium sand; thixotropic; roots absent. Abrupt, smooth boundary.

Depth/Horizon (cm)	
46-69 IVC1	Dark reddish grey (5Y 4/2) micaceous fine gravelly loamy fine sand; thixotropic; few roots. Frost 30 August 1977.

Site:	Finger Mountain #606.2
Slope:	2%
Vegetation:	see Profile #606.1
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Live vegetation. Sphagnum.
0-14 Oi1	Reddish brown (5YR 5/4-4/4) fibric organic; loose; roots common. Abrupt, smooth boundary.
14-23 Oi1	Dark reddish brown (5YR 3/2) yellowish red (5YR 4/6) pressed fibrous organic; breaks down with difficulty; weak fine platy structure; few roots. Abrupt, smooth boundary.
23-32 Oe1	Dark reddish brown (5YR 2.5/2); dark reddish brown (5YR 2.5/2) pressed hemic sedge peat; breaks down with difficulty; moderate fine platy; few roots. Abrupt, wavy boundary.
32-44 IIC1	Dark greyish brown (2.5Y 4/2) micaceous fine gravelly loamy fine sand; roots common; upper 2 cm concentration of a dark yellowish brown (10YR 3/4) coarse sand and fine gravel; thixotropic. Lower boundary not observed. Frost at 74 cm. 30 August 1977.

Site:	Finger Mountain #606.3
	Surface topography smooth; few exposed boulders.
Slope:	2%
Vegetation:	Lichens, <u>Ledum palustre</u>; <u>Betula papyrifera</u>; scattered <u>Picea mariana</u>; <u>Alnus viridis</u>
Classification:	Pergelic Cryochrept
Depth/Horizon (cm)	
3-0	Live vegetation - moss, lichens
0-3 A1	Black (7.5 YR N2/) organic silt loam; weak coarse subangular blocky structure; many roots. Abrupt, wavy boundary.
3-5 E	Pinkish gray (7.5YR 7/2) loamy coarse sand; quartz grains clear; fine earth component present; fragments of unweathered granite common. Abrupt, irregular to pendant boundary (tongues to 8 cm).
5-16 B21	Strong brown (7.5YR 5/6) fine gravelly loamy coarse sand; moist; friable; discontinuous silt coats on fragment tops; breaks to weak coarse subangular blocky structure; few roots. Abrupt, wavy boundary.
16-37 B22	Yellowish brown (10YR 5/6) fine gravelly coarse sand; moist; friable to loose; coarse fragments (20%) have discontinuous silt coats; gravel fragments are angular; few roots; inclusions of light yellowish brown (10YR 6/4) silt loam; weak to moderate fine granular to subangular blocky structure. Abrupt, wavy boundary.

Finger Mountain #606.3

Depth/Horizon (cm)	
37-50 B3	Yellowish brown (10YR 5/4) fine gravelly medium sand; moist; friable; fine gravel (10%); fragments have discontinuous silt coats; most quartz grains clear; absent. Clear, wavy boundary.
50-75 C1	Yellowish brown (10YR 5/4) fine gravelly medium sand; few cobbles; coarse material becomes more common near base; roots absent. Abrupt, wavy boundary.
75+ IIC2	Yellowish brown (10YR 5/4) gravel; discontinuous silt coats on fragment tops. Profile terminated.

Site: Finger Mountain #608.1

Solifluction slope; scattered rocks on surface.

Slope: 8%

Vegetation: Scattered *Picea mariana* (mostly $<$ 4m high) stumps and corpses common; *Alnus viridis*; *Betula glandulosa*; *Ledum palustre*; *Vaccinium uliginosum*; *V. vitas-idaea*; *Sphagnum* sp.; *Cladonia alpestris*

Classification: Histic Pergelic Cryaquept

Depth/Horizon (cm)	
0-17 Oi1	Dark yellowish brown (10YR 4/6 broken face and crushed) fibric organic (*Sphagnum*); well matted. Clear, smooth boundary.
17-25 Oi2	Dark yellowish brown (10YR 4/4) broken face and crushed) fibric (*Sphagnum*) well mottled. Abrupt, smooth boundary.
25-33 Oa1	Very dark brown (10YR 2/2) sapric organic; matted; large rocks begin at 30 cm; few roots. Clear, smooth boundary.
33-39 A1	Black (10YR 2/1) sapric organic; very weak fine granular structure; 3-4% pebbles; roots common to many. Abrupt, smooth boundary.
39-51 IIC1g	Dark grey (10YR 4/1) coarse sandy loam; thixotropic; few medium dark yellowish brown (10YR 4/4) mottles; 10% fine ($<$ 1 cm) gravel; few very dark grey (10YR 3/1) patches of organic fine sandy loam; roots common. Frost. 7 September 1978.

Site:	Finger Mountain #610.2
Slope:	4%
Vegetation:	Sphagnum sp.; scattered forbs, Carex sp.
Classification:	Histic Pergelic Cryaquept
Depth/Horizon (cm)	
6-0	Live vegetation; Carex and Sphagnum
0-8 Oil	Strong brown (7.5YR 5/6) wet; reddish yellow (7.5YR 6/6) pressed; fibric organic; loose; many roots; weak medium platy structure. Abrupt, smooth boundary.
8-19 Oel	Dark reddish brown (5YR 2.5/2) wet; dark reddish brown (5YR 3/4) pressed; hemic organic; mostly fine roots; moderate fine platy structure; root fragments abundant; sedge fragments common; live roots common. Abrupt, smooth boundary.
19-25 A1	Very dark brown (10YR 2/2) fine gravelly organic silt loam; coarse angular feldspar granules; few charcoal fragments; many root and stem fragments. Abrupt, smooth boundary.
25-38 IIB2	Dark brown (10YR 3/3) very fine gravelly coarse sand; few coarse angular feldspar fragments; many roots concentrated in upper 8 cm of horizon. Abrupt, wavy boundary.
38-46 IIIC1g	Black (5Y 2.5/2) very fine gravelly loamy fine sand; few fine prominent dark brown (10YR 3/6) mottles; few charcoal fragments; roots common; thixotropic. Frost. 1 September 1977.

Site:	Finger Mountain #610.1
	Boulder stripe area 180-250 m from divide.
Slope:	4%
Vegetation:	*Betula glandulosa*; *Ledum palustre*; *Cladonia* sp.
Classification:	Pergelic Cryaquept
Depth/Horizon (cm)	
3-0	Living vegetation
0-5 Oi1	Dark reddish brown (5YR 3/3) fibrous mat composed mostly of dead fine roots; loose; living coarse roots common. Abrupt, smooth boundary.
5-8 Oi2	Reddish grey (5YR 5/2) and reddish brown (5YR 5/3) fibrous moss; little sedge material; clear, coarse quartz sand grains common. Abrupt, smooth boundary.
8-15 Oa1	Dark reddish brown (5YR 2.5/2) sapric organic; friable; structureless to weak fine granular structure; uncoated quartz grains common; fine roots common. Black (5YR 2.5/1) color common at boundary (possible humates or charcoal). Abrupt, wavy boundary.
15-23 IIB2	Dark brown (10YR 3/3) fine gravelly medium and coarse sand; friable; roots absent. Abrupt, wavy boundary.
23-28 IIIB23g	Dark yellowish brown (10YR 4/4-4/6) fine gravelly loamy fine sand; common strong medium strong brown (7.5YR 5/6) mottles; common medium moderate dark greyish brown (2.5Y 4/2) mottles; friable; structureless. Abrupt, smooth boundary.

Depth/Horizon (cm)	
28-46 IIIC1	Olive brown (2.5Y 4/4) gravelly loamy fine sand; friable; wet; roots, between 28 to 30 cm. Dark greyish brown (2.5Y 4/2) gravelly loamy fine sand; thixotropic. Abrupt, wavy boundary.
46-56 IIIC2	Dark brown (10YR 3/3) fine gravelly medium and fine sand; wet; thixotropic; few roots. Frozen at 66 cm. 1 September 1977.

Site:	Finger Mountain #606.20
	Slope of narrow ridge (well drained) surrounded by split pools and hummocks.
Slope:	est. 20%
Vegetation:	<u>Picea mariana</u>; 50% <u>Cladonia alpestris</u>; <u>Ledum palustre</u>; <u>Empetrum eamesii</u> and <u>Betula glandulosa</u>
Classification:	Pergelic Cryochrept
Depth/Horizon (cm)	
2-0 O1	Loosely matted lichens and fine roots.
0-2 A1	Black (10YR 2/1) sapric organic; matted with many fine roots. Abrupt, smooth boundary.
2-4 E	Yellowish brown (10YR 5/4 moist) coarse sandy loam; weak fine granular structure; 7% fine quartz gravel (1 cm ±); many fine roots. Abrupt, smooth boundary.
4-8 B21ir	Dark yellowish brown (10YR 4/4) loam; 20% fine angular quartz gravel; medium fine subangular blocky structure; very fine patchy silt coats; many fine roots. Abrupt, smooth boundary.
8-17 B22	Yellowish brown (10YR 5/6) loam; medium subangular blocky structure breaking to moderate very fine granular; 10% fine pebbles with thin continuous silt coats. Gradual, smooth boundary.

Finger Mountain #606.20

Depth/Horizon (cm)	
17-24 B21b	Dark brown (7.5YR 4/4) silt loam; moderate fine angular blocky structure; 6% fine gravel fragments with continuous thin silt coats; few roots. Abrupt, smooth boundary.
24-46 C1	Dark yellowish brown (10YR 4/4) loam; ~ 22% clay; very fine platy structure breaking to moderate very fine subangular blocky; 10% fine gravel fragments (< .5 cm) with continuous thin dark yellowish brown (10YR 4/4) silt coats; few fine roots. Profile terminated.

Appendix C

Area (% of Total) summary for all soil-landform map units appearing in Fig. 68.

Map Unit	% of Area	Map Unit	% of Area
1,1,2	.1	5-2,9,1	.2
1-2,3,1	.5	5-2,9,2	.8
1-2,3,2	1.9	5,10,2	.04
1-2,3,3,	.7	6,8,3	6.3
1-2,5,3	2.9	12,1,1	.4
1-2,7,2	4.6	12,3,2	.04
1-2,7,3	10.0	12,4,2	2.6
1,3,1	.4	12,4,3	4.7
1,3,3	.03	12,7,1	.1
1,6,3	3.0	12,7,2	1.2
1,7,3	.2	12,7,3	.5
1,10,3	1.1	21,4,2	2.4
2,1,3	.2	21,4,3	7.4
2-1,4,3,	1.1	21,5,1	.2
2-1,7,3	2.8	21,5,3	1.0
2-1,9,2	.2	21,6,1	1.0
2,4,3	.9	21,6,2	11.0
2,9,2	.2	21,6,3	15.1
2,10,2	1.4	21,7,1	4.1
2,10,3	.8	52,9,3	.5
4,2,1	3.8		
4,2,2	2.4		
5-2,6,3	1.4		

No Name Creek Site

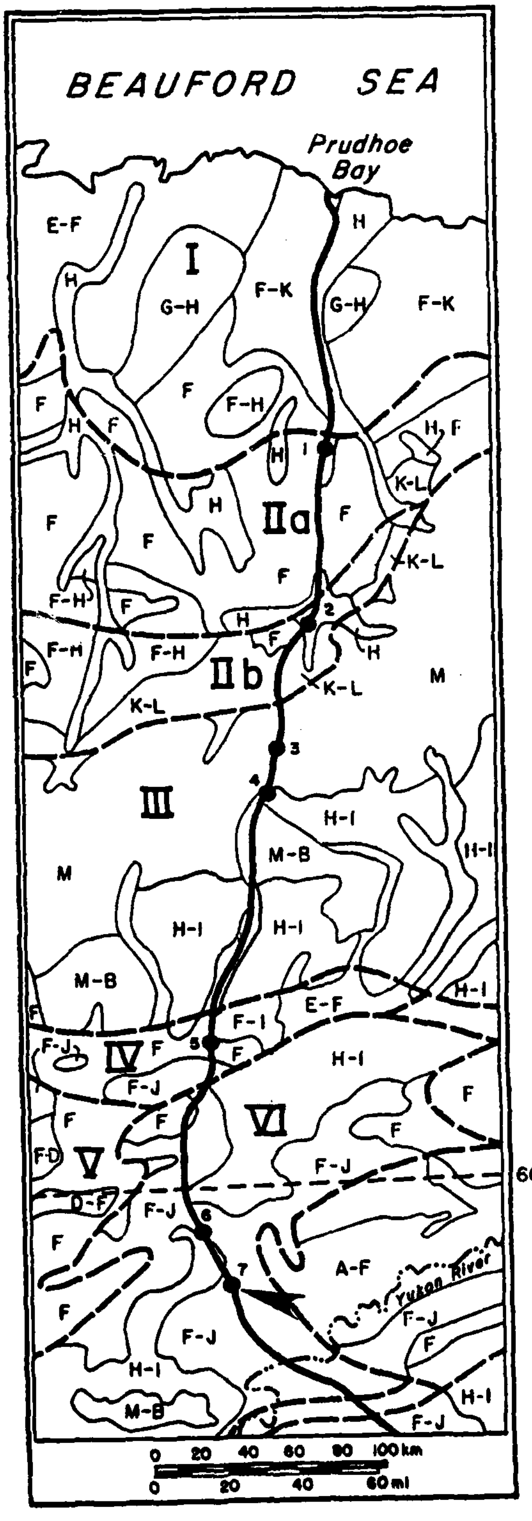


Fig. 71. Location of the No Name Creek site (7) with respect to regional physiographic and soils boundaries.

Physical Geography

Geology

The No Name Creek site is approximately 23 miles (37 km) north of the Yukon River crossing (Fig. 1) and within the Kokrine-Hodzana Highlands physiographic province (Wharhaftig, 1965). The entire map area is underlain by Quaternary deposits. The long, gentle, generally south facing slopes are underlain by fine sands and silts. These materials probably originated in the flood plain of the Yukon River and were transported by wind. Subsequent to deposition they have been reworked by slope wash and solifluction and in some cases incorporated with sands and rounded quartz rich gravels. These gravel deposits, also of Quaternary (Kachadoorian, 1971) are comprised of high level terrace remnants, some occupying more than 1 km^2, that occur to 78 m or somewhat more above the creek. They are also probably related to a more expanded phase of the Yukon River. The broad (0.5 to 0.75 km) tussocky lowland on the north side of the stream that comprises the central part of the map area is underlain by fine grained lacustrine materials,again of Quaternary age. Several small, low elevation gravel terrace remnants occur adjacent to the lowland. They may be part of the sequence of higher level gravels or fan deposits composed of eroded gravels.

No Name Creek is confined to the south side of the tussocky lowland and meanders within a flood plain that is generally less than 200 m wide and is flanked by fine grained overbank deposits.

The pre-Quaternary rocks that underlie the area but do not crop out at the map site are lithologically similar to those of the Finger Mountain area 25 km to the north, namely Paleozoic schists, phyllites and greenstones, ultramafic intrusions and Cretaceous granites (Fig. 2, pg. 8).

Topography and surface forms

No Name Creek drains a portion of the Fort Hamlin Hills immediately south of the map area where summit elevations reach in excess of 850 m. On the north a broad divide (summit elevation to 850 m) separates the No Name Creek drainage from that of the Kanute River. From this divide and below an elevation of 300 m a series of parallel streams cross a long (8 km) relatively uniform slope to No Name Creek (Fig.72).

The creek itself has a tortuous and somewhat ingrown meander pattern. Although it presently occupies a narrow meander belt on the south side of a broad valley filled with lake sediments there is some evidence,in the form of a filled oxbow,that it or a tributary may have meandered briefly over the lacustrine sediments after drainage of the lake sometime before 3750 ± 150 years B.P. (GX 5111).

Within the map area and to the south of the creek, slopes are complex. Abrupt relief differences of 10 m or more occur adjacent to the creek where it is actively cutting into colluvial deposits. In other areas the colluvial slopes display a ridge and watertrack pattern similar to that of the long south-facing slope. Both valley slopes have well developed microrelief consisting of discontinuous non-sorted stripes - a pattern similar to that described at Tramway Bar. The north facing slope just to the east of the pipe, as it makes its bend toward the stream, has a pattern of small polygons, 40-45 cm in diameter and up to 15 cm high. Near the steeper lower part of this slope mineral soil is exposed at the surface of the polygons.

Large diameter ice wedge polygons occur but their topographic expression is slight and obscured by the dense spruce forests on slopes -

Fig.72. View to the southeast along winter road line (see Fig.7[illegible]) showing the long uniform south facing slope. The pipeline can be seen in extreme upper right or skyline as it ascends the steep north-facing slope on to high level gravel terrace. Black spruce (P. *mariana*) forest appears to be nearing maturity.

if indeed they occur on the slopes at all and by the large tussocks in the lowland meadows. A sporadic and poorly expressed pattern of large diameter polygonal cracks can be seen on some gravel surfaces (see Fig. 76).

Permafrost

The area of the No Name Creek site like that of Finger Mountains is included within the zone of discontinuous permafrost. In all probability however, permanently frozen ground exists beneath all topographic elements. Excavations and limited September soil temperatures suggest that on the broad high level gravel terrace remnants, permafrost may be 5 m or more below the surface and that seasonal surface freezing may not encounter the permafrost. On the long spruce covered south-facing slopes seasonal thaw ranges between 45 and 60 cm with mineral soil stripes thawing most. In well-drained areas with white spruce (*Picea glauca*) where loess overlies terrace sands and gravels seasonal thaw reaches 1.2 m. A somewhat shallower thaw (45 cm) is probably characteristic of at least the wetter portions of the north-facing slopes.

Within the wet tussock meadows, permanently frozen ground containing a moderate amount of ice in thin lenses (1-2 mm) occurs at 28-30 cm below the surface in intertussock areas. Within the organic soils of the filled oxbow ponds thaw reaches 55 cm.

It has already been noted that ice wedge polygons, forms commonly associated with permafrost areas, are (if present) masked by vegetation in most of the area. The elevated mode of the pipeline across the map site, including the south-facing slopes suggests permafrost contains

considerable ice probably in the form of ice wedges. The poorly expressed polygonal patterns that do occur are found in the wet tussock meadows and are almost impossible to see except on aerial photographs.

The abundant mineral soil stripes so characteristic of the slopes are indicative of a periglacial climate with considerable frost activity in wet soils. Their formation does not however, require permafrost.

Vegetation

The vegetation communities that occur over much of the soils map area have been described and mapped in detail by Walker and Webber (1979). Four principal communities can be identified with respect to soils: (1) a closed evergreen forest composed of *Picea mariana* with trunk diameters generally less than 5 cm dbh; and an understory of *Vaccinium uliginosum*; *V. vitis-idaea*; *Empetrum eamesii*; *Ledum gröenlandicum* and numerous mosses and lichens (Fig.73). This and similar communities are formed on moist silt and/or colluvial north or south-facing slopes. These are typically areas of Histic Pergelic Cryaquept and Pergelic Cryaquept soils (see Figs.72 and 76); (2) open mixed forests on high level gravel terrace remnants composed of *P. glauca Betula papyrifera* with dbh's of 5-15 cm and understories characterized by *E. eamesii*, *V. vitis-idaea*; *V. uliginosum* and lichens especially *Cladonia* spp. Associated soils are Pergelic(?) Cryorthents; (3) wet lowland tussock-graminoid meadow consisting of *Eriophorum vaginatum*; *Betula glandulosa*; *Salix planifolia* and *Chamaedaphne calycullata*. Soils are predominately Histic Pergelic Cryaquepts and Pergelic Cryaquepts; (4) transitional communities mostly of open evergreen forests composed of short, small diameter *P. mariana* (dbh $\leq$ 5 cm) with

Fig. 3. Closed canopy black spruce forest *Vaccinium uliginosum*, *V. vitis-idaea*; *Empetrum camesii* and *Ledum groenlandicum* are the principal understory. Permafrost ranges between 45 and 60 cm. Soils are mostly Histic pergelic Cryaquepts.

the understory commonly containing Eriophorum vaginatum along with Betula glandulosa; Salix planifolia and Sphagnum sp. Soils are characteristically Histic Pergelic Cryaquepts.

Soils

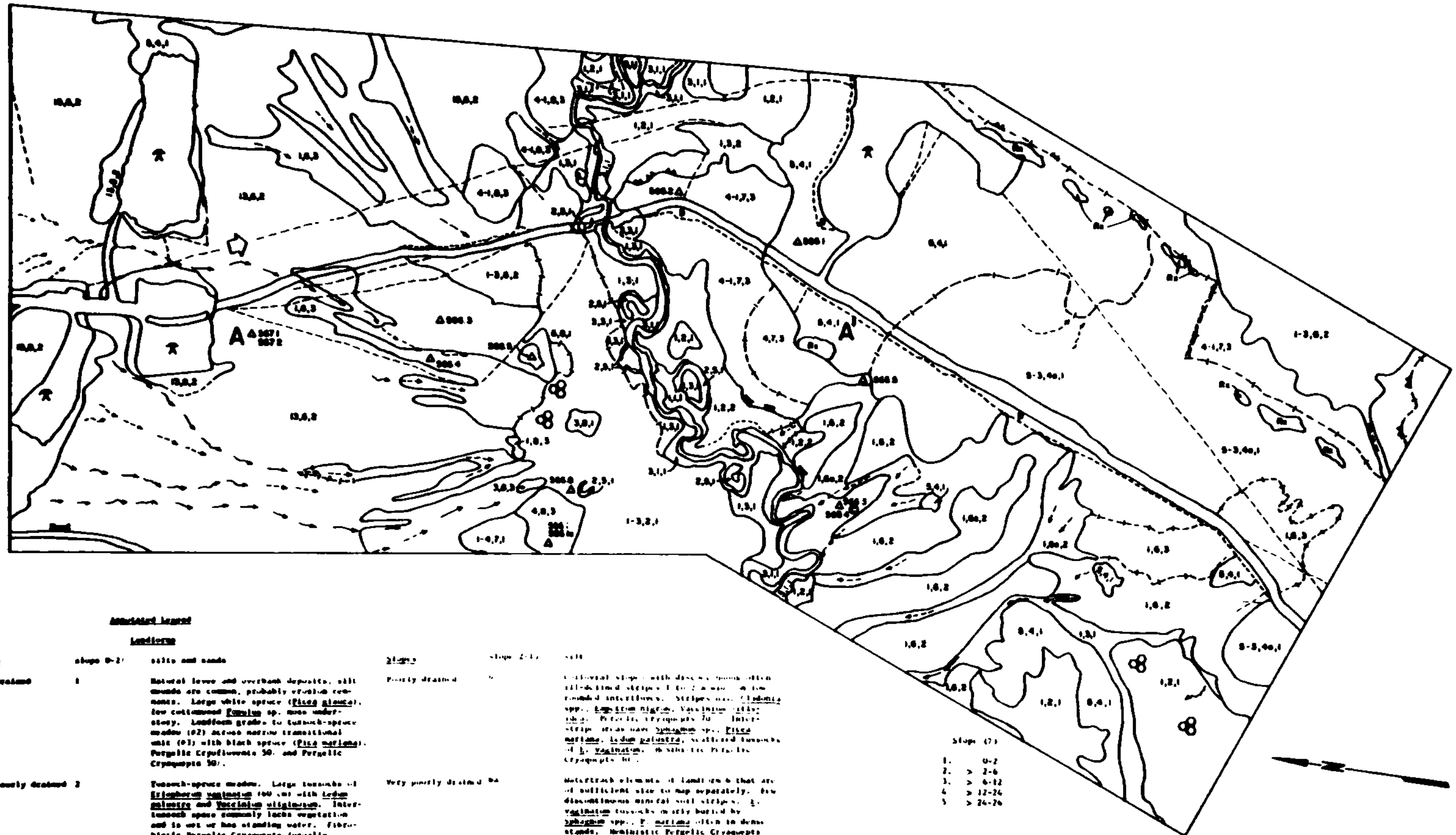
Soils in the No Name Creek area are fine textured-silt loams- in contrast, for example, to the loam and sandy loam soils of the Finger Mountain site 27 kilometers to the north. The areas have similar bedrock and are included within the same soil association on the regional soils map, Figs. 10 and 71. The reason for the textural difference lies in the amount of windborne silts (loess) added to the landscape near the Yukon River.

Well drained soils are associated with clean, well sorted quartz-rich fluvial gravels. Within the map area these materials are exposed most commonly on gently sloping uplands and ridges projecting from them. In such cases the loess mantle has been removed for the most part. The soils are deeply thawed and generally the most acid in the area. Horizon differentiation is poor and this, coupled with their coarse texture, places them in the Order Entisols, suborder Cryorthents (Fig.74). It is questionable whether the term Pergelic (denoting permafrost) should be used. Even if it is present it is at a depth to great to influence soil development.

Sites on which these soils develop have a thin, species poor vegetation composed of paper birch (Betula papyrifera) and a discontinuous ground cover of lichens and heath (Fig.75). Many of the birch trees are

SOIL LANDFORM MAP

Mile 21.2 — Mile 23.0 TAPS Haul Road



Annotated Legend

Landform

Slopes	slope 0-2%	silts and sands		
Well drained	1	Natural levee and overbank deposits, silt mounds are common, probably erosion remnants. Large white spruce (Picea glauca), few cottonwood Populus sp. moss understory. Landform grades to tussock-spruce meadow (#2) across narrow transitional unit (#3) with black spruce (Picea mariana). Pergelic Cryofluvents 50% and Pergelic Cryaquepts 50%.		
Very poorly drained	2	Tussock-spruce meadow. Large tussocks of Eriophorum vaginatum (60 cm) with Ledum palustre and Vaccinium uliginosum. Intertussock space commonly lacks vegetation and is wet or has standing water. Fibrohistic Pergelic Cryaquepts (usually tussocks), 60%. Intertussock areas have Saprohistic Pergelic Cryaquepts (40%).		
	3	Transitional tussock-spruce slopes. Tussocks of Eriophorum vaginatum, considerable Sphagnum spp., small black spruce (P. mariana) and spruce corpses. Silty clay loam and silt loam mineral horizons. Fibrohistic Pergelic Cryaquepts 50%; Saprohistic Pergelic Cryaquepts 50%.		
	3a	Similar to unit 3 but with gravelly loam mineral horizons.		
Slopes	slope 1-5%	quartz gravels		
Well drained	4	High level terrace remnants. Open stands of paper birch (Betula papyrifera), scattered white spruce (P. glauca), Cladonia sp. and Vaccinium vitis-idaea understory. Ant hills are common. Pergelic Cryorthents 100%.		
	4a	Similar to 4 with some tussocks.		
	slope 0%	organic materials		
Very poorly drained	5	Sedge (Carex sp.) meadows within filled oxbows. Standing water ≤ 10 cm common. Pergelic Cryofibrists 100%.		

Slopes	slope 2-1%	silt	
Poorly drained	6	Colluvial slopes with distinct but often ill-defined stripes 1 to 2 m wide with low rounded interfluves. Stripes have Cladonia spp., Empetrum nigrum, Vaccinium vitis-idaea. Pergelic Cryaquepts 70%. Interstripe areas have Sphagnum sp., Picea mariana, Ledum palustre, scattered tussocks of E. vaginatum. Histic Pergelic Cryaquepts 30%.	
Very poorly drained	6a	Watertrack elements of landform 6 that are of sufficient size to map separately. Few discontinuous mineral soil stripes. E. vaginatum tussocks mostly buried by Sphagnum spp., P. mariana often in dense stands. Hemihistic Pergelic Cryaquepts 80%, Pergelic Cryaquepts 20%.	
Moderately well drained	7	Colluvial slopes, polygonal hummock pattern common, hummocks 15 cm high and 40 to 45 cm in diameter, black spruce (P. mariana), some aspen (Populus tremuloides), paper birch (Betula papyrifera), Salix sp. and Alnus sp. Considerable fallen timber. Squirrel mounds of spruce cones are common. Pergelic Cryochrepts 80%, Saprohistic Pergelic Cryaquepts 20%.	
Well drained	8	Low level terrace remnants, variable thickness of calcareous loess over sands and gravels. Black spruce (P. mariana), white spruce (P. glauca), Salix sp., paper birch (B. papyrifera) occur commonly in open stands. Pergelic Cryochrepts 100%.	

Soils

1. Histic Pergelic Cryaquepts
2. Pergelic Cryofibrists
3. Pergelic Cryaquepts
4. Pergelic Cryochrepts
5. Pergelic Cryorthents

Slope (%)

1. 0-2
2. > 2-6
3. > 6-12
4. > 12-24
5. > 24-26

Boundaries and Geomorphic Symbols

- Soil boundaries and soil landform designations.
- Dashed line indicates probable soil boundary.
- Established drainage.
- Unconsolidated gravels exposed.
- Area of large diameter ice wedge polygons.
- Slopes in excess of 26%.
- Photographic point.
- A, A' Line of profile in Fig. 5

Cultural Symbols and Special Soil Symbols

- Pipeline workpad. D indicates disturbance.
- Access road to material site.
- Material site.
- Soil profile location. C denotes radiocarbon date.
- Winter trails.

MAP SYMBOLS

5,7,2

(Soil(s)), (Landform), (Slope)

Fig.75

small and corpses are abundant. A few spruce seedlings are usually present together with a few large, old white spruce (Picea glauca). The poor site quality probably reflects the very infertile nature of the soil in which exchangeable cations are present only in trace amounts (see Appendix A, profile 565.1 and Fig.76). The reason for this lies in the nature of the parent materials that are composed of 97 percent quartzitic sands and gravels and lack any significant percentage of weatherable minerals from which exchangeable cations can be released. Once subject to fire the reestablishment of vegetation is probably very slow.

Soils somewhat less well drained than the Cryorthents occur on steep colluvial slopes or on slopes where sands and gravels are overlain by silts. Such areas are easily identified by the presence of tall, relatively open stands of P. glauca (Fig.79) and a species-rich understory. The soils are silt loams and display a relatively well differentiated morphology and belong to the order of Inceptisols. They are tentatively placed within the Cryochrept great soil group. The term Pergelic is a required modifier (Pergelic Cryochrept).

An organic rich A horizon is underlain in most cases by what appears to be an illuvial (E) horizon. Removal of materials from this horizon however, cannot be substantiated chemically (see Appendix A, profiles 565.5 and 566.1). Some leaching of these profiles does occur to 0.5 m. Soil reaction in some cases increases from medium acid in the A and B horizons to slightly acid or neutral in the lower B horizon and C horizons and in a few profiles a strong reaction to HCL is noted in the C horizon.

Unlike the well drained, nutrient poor Cryorthents already discussed, the Cryochrepts have a relatively high percentage of exchangeable cations

Fig. 75. Vegetation and surface appearance of soil landform 5, 8, 1. High level gravels. Weakly defined polygonal cracks appear in center ground.

Fig. 76. Pergelic Cryorthent developed on gravels (A above).

and by virtue of their fine clay fraction and organic matter content have an equally high cation exchange capacity. The combination of good drainage and nutrient supply contribute to the relatively high forest site index on these soils. A certain amount of site instability results from windthrow and desiccation(?) cracking which may be especially significant following fire.

The less steep, poorly drained slopes occupied by black spruce (Picea mariana) or communities of spruce and tussocks have associations (when patterned ground occurs) or complexes of wet Inceptisols (Pergelic Cryaquepts and Histic Pergelic Cryaquepts) or have organic soils (Histosols) (Figs. 77 and 78). These soils have gleyed and mottled fine textured mineral horizons (silt loams) that reflect in their color the poor drainage resulting from the proximity of permafrost. Buried or enmixed organic materials and horizons are common. These soils all have significant amounts of exchangeable cations and are for the most part slightly alkaline to nearly neutral in reaction. In areas where Sphagnum or other mosses are a significant component of the ground cover organic horizons have developed over the mineral soil and are of sufficient thickness to require a modifying term Histic (if $>$ 20 cm but $<$ 40 cm) or are organic soils with organic horizons $>$ 40 cm thick. Terms reflecting decomposition state have been added to the Histic modifier.

Charcoal fragments occur in the soils of No Name Creek (they are however, not as abundant as at Finger Mountain). A charcoal tree stem fragment from a depth of 30 cm and at the September permafrost table yielded a modern radiocarbon date, i.e., the fire which produced the charcoal occurred less than 100 years before present. Contemporaneous

Fig. 77. Open black spruce slope with disconnected soil stripes accentuated by white lichens. Soils are shown below.

Fig. 78. Histic Pergelic Cryaquept (histic epipedon only) left. Pergelic Cryaquept (right) developed in soil stripe.

with the fire and possibly subsequent to it, existing organic materials were oxidized (to the sapric state). Following this period sedge became abundant, producing a fibrous peat which was followed in turn by fibrous moss peat. At least 20 cm of post fire organic materials have accumulated on the slope.

Intermittent mineral soil stripes are an important feature of the wet black spruce slopes. Soils of these features are Pergelic Cryaquepts, (see profile 565.4, Fig. 78).

Pergelic Cryaquepts are also found associated with the overbank deposits adjacent to No Name Creek. They are more deeply thawed and better drained than those of the slopes and as a consequence of this they support large, old (150-200 + years) white spruce.

Tussocks of Eriophorum vaginatum are a significant component of the black spruce slopes especially on the lower flatter areas. If the tussock itself is considered an organic horizon Pergelic Cryofibrists form an association with Hemihistic or Saprohistic Cryaquepts (see profiles 566.4 and 566.5, Fig.79).

The most extensive tussock area occurs in the flat lowland north of No Name Creek (Fig.74) and is coextensive with the deposits of the former lake. Several other tussock areas occupying former lake basins occur in the broader area around No Name Creek.. The single radiocarbon date from the tussock area indicates that the organic soil horizons are no older than 3750 years, the time near that for the drainage of the lake. Soil landscapes of similar character occur in the Koyukuk flat area to the north.

Within the lake basin are small areas of organic soils that occupy one time meander scars (oxbows) related to a stream or streams that once

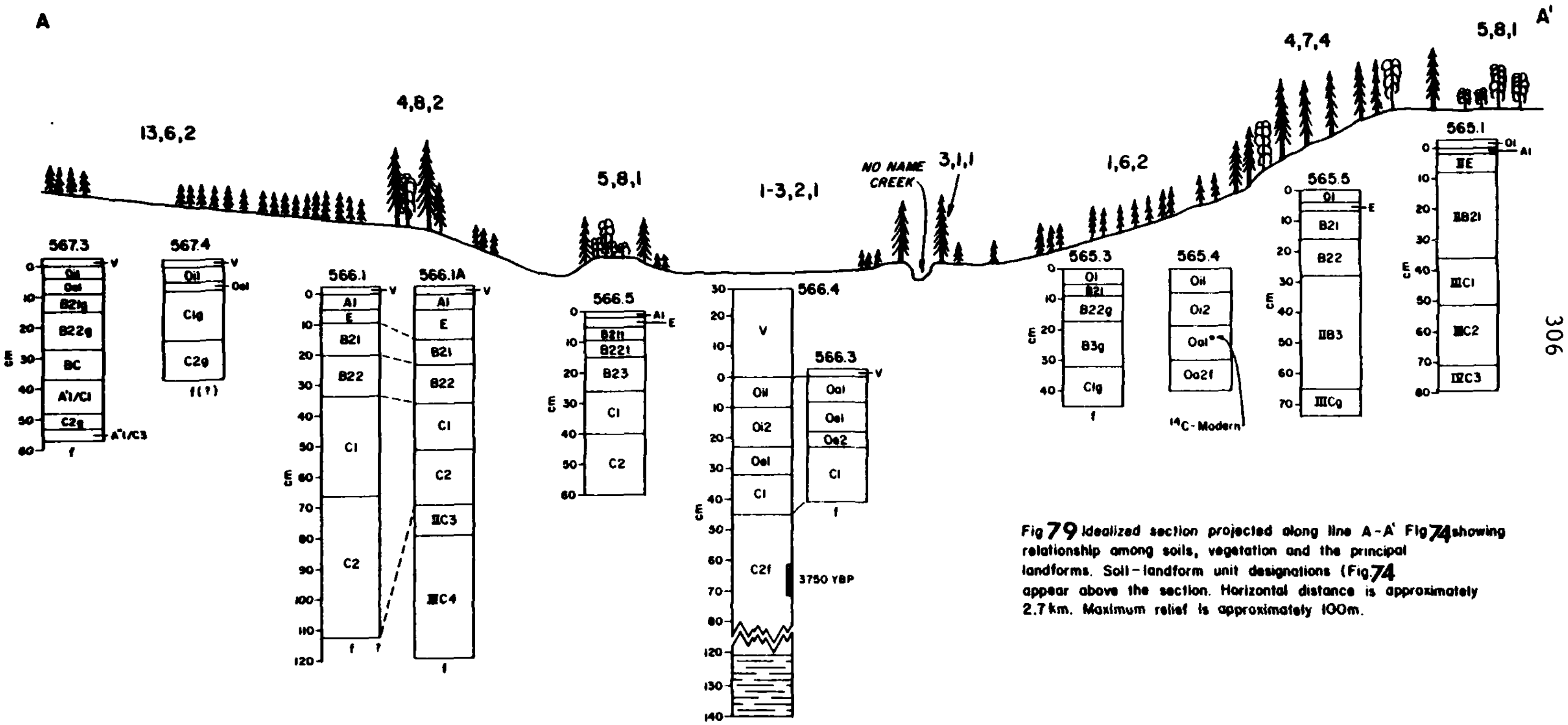


Fig 79 Idealized section projected along line A-A' Fig 74 showing relationship among soils, vegetation and the principal landforms. Soil-landform unit designations (Fig 74 appear above the section. Horizontal distance is approximately 2.7 km. Maximum relief is approximately 100m.

crossed the drained lake surface. Although the organic horizons are thick (> 55 cm) the amount of <u>Sphagnum</u> moss in the profile may preclude their inclusion within the Histosols (see criteria in soil taxonomy, Soil Survey Staff, 1975). In any case organic horizons below the <u>Sphagnum</u> are composed of sedge materials.

Landscape Evolution

Although the gross aspects of the No Name Creek landscape probably existed well before the advent of Quaternary glaciation, it is largely the geological events of this period that have contributed to the detailed soil landscape. Of particular significance was the deposition in the area of well sorted gravels and coarse sands to elevations exceeding 280 m. These deposits may be related to similar gravels and sands to the east (Brosgé <u>et</u> <u>al</u>., 1973) and thus are probably deposits of a more expanded phase of the Yukon River. Within the No Name Creek area erosion has removed and/or redistributed a significant amount of these gravels leaving them on the uplands and as disseminated patches on hill slopes.

Subsequent to emplacement of the gravels, loess, derived from the broad, braided valley of the Yukon River east and north of the Fort Hamlin Hills blanketed the No Name Creek area. These deposits which apparently did not reach, or are unrecognizable, much farther north (Kachadoorian, 1971) are extensive south of the Yukon River. Erosion including solifluction has apparently removed them from many of the upper slope areas and re-distributed the fines lower down. Loess over sorted gravels is a common occurrence in the map area.

Several lakes between 1 and 3 km in length occupied closed depressions for some unknown length of time until they became filled with sediments and/or drained. The central portion of the map area is the site of one such former lake now occupied by tussock tundra. The fine textured sediments filling this basin were undoubtedly eroded from the surrounding slopes. This lake existed until at least 3700 years ago. Once filled with sediment and/or drained, presumably by No Name Creek, a sedge fen developed and finally evolved to the present tussock meadow.

Ice rich permafrost has developed beneath much of the area and is maintained in a climate generally similar to that north to the region of Prospect Creek. Large ice wedge polygons have formed in the lake sediments (and probably in the fine textured sediments of the slopes as well).

Appendix A
Selected Edaphic Characteristics

List of Annotations

1	Soil pH determined in field. 1:5 soil/water suspension
2	Soil pH determined in laboratory. 1:1 soil/water paste
3	Right hand. Column values determined on silt coatings removed from upper surface of cobbles. Values in left hand column or in single columns were determined on soil matrix.
4	Field colors determined with Munsell color chips.
5	Refer to Appendix B and figures
T	Trace amount ($<$ 1%)
DC	Citrate-dithionite extraction
OX	Ammonium oxylate extraction
SP	Sodium pyrophospate extraction
VC	Very coarse sand 1-2 mm; C coarse sand 1-0.5 mm; M medium sand 0.5-0.25 mm; F fine sand 0.25-0.10 mm; VF very fine sand 0.10-0.05 mm; TOT total sands.
C	Coarse silt .50-20 μm; F fine silt 20-2 μm.
C	Coarse clay 2-0.2 μm; F fine clay $<$ 0.2 μm.

Text Class: s sand; si silt; c clay; l loam; cs, csl, lcs = coarse sand, coarse sandy loam; loamy coarse sand; fsl fine sandy loam; cl, sicl clay loam; silty clay loam.

No Name Creek
Selected Edaphic Characteristics

Soil[5] Profile	Depth (cm)	Horizon	Color[4]	% Organic carbon	Exchangeable Cations Meq/100 g Ca	Mg	K	H	Fe(%) CD	Fe(%) OX	Fe(%) SP	Al(%) CD	Al(%) OX	Al(%) SP	pH	Particle size: sands mm(%) VC	C	M	F	VF	TOT	silt/clay μm(%) silt C	silt F	clay C	clay F	Text Class
565.1	0-2	A1	10YR2/1	5.82											4.2[1]											
	2-8	E	10YR5/3	7.45					1.53	0.02	0.01	0.04	0.04	0.04	4.1	53	29	8	6	2	97	-	3	1	-	cs
	8-36	B21	10YR5/6	0.22	0.1	T	0.04		0.76	0.10	0.03	0.09	-	0.13	5.2	63	26	5	3	T	97	T	3	1	-	cs
566.5	0-2	A1	7.5YR2/1	16.89	29.5	5.1	0.78								5.8[2]											
	2-5	E	10YR4/4	2.81	4.7	1.2	0.17		1.44	0.43	0.15	0.18	0.18	0.13	5.2	14	11	4	4	2	34	24	32	7	3	sil
	5-9	B21	7.5YR4/4		3.2	0.9	0.13		1.44	0.28	0.09	0.18	0.16	0.09	5.8	11	9	3	3	2	29	26	36	8	2	sil
	9-15	B22	10YR4/4		2.9	1.1	0.10		1.35	0.20	0.05	0.17	0.13	0.05	5.6	14	13	4	4	2	37	24	31	8	2	sil
	15-26	B23	10YR4/4		3.6	1.7	0.10								5.6	15	18	10	10	5	57	16	14	9	5	csl
	26-40	C1	10YR4/4		3.1	1.3	0.07								5.6	29	31	9	9	4	80	7	5	4	3	lcs
	40-60	C2	10YR4/4												5.7	63	20	4	4	2	92	2	2	3	1	cs
565.5	0-4	A1	10YR3/2	43.41											4.7[2]											
	4-7	E	10YR3/3	23.51	20.2	4.5	0.92								4.5	T	T	T	1	2	3	28	32	14	24	sicl
	7-16	B21	10YR4/4	1.77	15.0	4.8	0.19		2.15	0.17	0.69	0.25	0.20	0.69	5.4	2	3	2	3	5	15	37	31	9	8	sil
	16-28	B22	10YR4/4	0.64	17.3	5.8	0.17		2.49	0.54	0.31	0.20	0.14	0.22	5.8	4	4	2	3	7	19	34	31	9	6	sil
	28-65	IIB3	10YR4/4												6.2	9	9	5	9	8	40	24	21	9	7	l
	65-74	IIIC/g	10YR4/2												6.5	13	5	2	2	6	28	34	25	8	6	sil
565.2	0-5	A1	7.5YR3/2												4.1[1]											
	5-11	E	10YR3/3		14.5	7.0	0.29								4.8	4	3	1	3	4	15	27	40	12	6	sil
	11-27	B21	10YR4/3		15.6	7.0	0.17								5.7	5	3	1	2	6	17	31	40	10	2	sil
	27-44	B22	10YR3/3		17.6	8.0	0.17								6.3	7	4	1	2	6	19	29	38	11	3	sil
	44-62	B3	10YR4/3		20.1	10.2	0.20								6.4	7	7	3	5	11	32	28	29	9	3	sil
566.1	0-5	A1	5YR2/2	42.79											5.6[1]											
	5-15	E	10YR3/2	8.17	34.4	4.0	0.14								6.2	T	1	1	1	5	8	36	39	12	6	sil
	15-23	B21	10YR5/3		19.0	2.3	0.14								6.1	T	1	1	2	8	12	37	39	9	4	sil
	23-36	B22	10YR5/3		14.9	2.0	0.13								6.5	T	1	1	2	9	12	34	37	13	3	sil
	36-51	C1	10YR5/3	1.19	15.2	1.6	0.15								7.2	T	T	T	1	10	12	36	39	10	3	sil
	51-69	C2	10YR5/2												7.1	2	4	3	4	12	25	31	33	9	2	sil
	69-79	IIC3	10YR5/3												HCL											
	79-119	IIIC4	10YR4/2												HCL											
565.3	0-5	O1	10YR4/4	4.33	18.4	4.6	0.15								6.3[2]	1	1	T	1	4	7	37	38	11	7	sil
	5-9	B21	10YR4/1	2.17	13.4	3.2	0.11								6.2	0	T	T	1	5	6	39	39	10	6	sil
	9-17	B22g	10YR4/3	2.27											6.5	0	T	T	1	4	6	37	40	11	6	sil
	17-32	B3g	5Y4/1												--											
	32-45	C/g	5GY4/1	1.83											6.7	0	1	T	1	5	7	40	38	10	6	sil

Appendix B

Selected profile descriptions of the soils of the No Name Creek area. Refer to Figs. 74 and 79 and Appendix A for topographic setting and edaphic characteristics.

Site: No Name Creek #565.1

Lichen bald upland (see diagram #565.2). Upland crest or near crest, small 1-2 m diameter polygons with little relief.

Slope: 0-4%

Vegetation: Aspen (broused), scattered *Picea glauca*, *Cladonia* ssp., some *Vaccinium uliginosum* and *Salix* sp.

Classification: Pergelic(?) Cryorthent

Depth/Horizon (cm)	
3-0 01	Lichen mat and leaf litter
0-2 A1	Black (10YR 2/1) organic silt loam; friable; fine granular; angular quartz fragments; uncoated; many roots. Abrupt, wavy boundary.
2-8 E	Brown (10YR 5/3) organic rich coarse sand; somewhat massive (weak cement); fine roots common; few coarse roots. Abrupt, wavy boundary.
8-36 B21	Yellowish brown (10YR 5/6) coarse sand; few coarse gravel fragments; iron stained bottoms; no roots below 20 cm. Abrupt, wavy boundary.
36-41 C1	Yellowish brown (10YR 5/4) fine gravelly coarse sand; roots absent. Abrupt, wavy boundary.
41-71 C2	Light olive brown (2.5Y 5/4) very fine gravelly coarse sand; fine gravel increases downward; roots absent. Abrupt, wavy boundary.

No Name Creek #565.1

Depth/Horizon (cm)	
71-79 C3	Brown (10YR 5/3) medium sandy gravel, massive; breaks to weak medium angular blocky units; gravel is angular to subrounded. Profile terminated.

Site: No Name Creek #565.2

Hummocky solifluction slope (reticulate pattern) hummocks 40-46 cm wide by 15 cm high.

Slope: ~ 10%

Vegetation: Vegetation dense *Picea mariana* 3-4 m, a few to 6 m.

Ledium palustre moss; *Vaccinium vitis-idaea*; *Empetrum eamesii*

Classification: Pergelic Cryochrept

Depth/Horizon (cm)	
5-0	Living mat *Empetrum* and *Vaccinium*, *Ledum*, moss
0-5 A1	Dark brown (7.5YR 3/2) organic (Sapric) organic silt loam. Very weak fine granular structure to structureless; sporadic quartz gravel fragments; fungal hyphae abundant near surface; roots abundant; charcoal fragmenta common. Abrupt, wavy to interrupted boundary.
5-11 E	Very dark greyish brown (10YR 3/2) to dark brown (10YR 3/3) silt loam. Colors mixed; charcoal fragments common in (10YR 3/2) areas; friable; breaks to weak fine subangular blocky structure; roots common. Abrupt, wavy boundary.
11-27 B21	Dark brown (10YR 4/3) silt loam; friable; weak medium subangular blocky structure; granules common; few basalt cobbles; roots common. Abrupt, wavy boundary.
27-44 B22	Dark brown (10YR 3/3) silt loam; friable, breaks to strong and moderate medium angular blocky structure; basalt cobbles 5%; roots few. Abrupt, wavy boundary.

No Name Creek #565.2

Depth/Horizon (cm)	
44-62 B3	Dark brown (10YR 4/3) silt loam; friable, breaks to weak fine subangular blocky structure; dark brown (10YR 3/3) around basalt fragments; cobbles (30-40%) increasing to 50-60% below 62 cm. Profile terminated.

Site: No Name Creek #565.3

Waterways and few silt stripes - tussocks nearly engulfed in moss.

Site in stripe.

Slope: ~ 10%

Vegetation: Picea mariana; Eriophorum vaginatum; moss.

Classification: Pergelic Cryaquept

Depth/Horizon (cm)	
0-5 01	Dark yellowish brown (10YR 4/4) hemic organic; loosely matted. Abrupt, smooth boundary.
5-9 B21	Dark grey (10YR 4/1) grey (10YR 5/1) silt loam; weak very fine granular structure; some enmixed organic in upper 1 cm; many fine roots. Abrupt, smooth boundary.
9-17 B22g	Dark grey (10YR 4/1) silty clay loam; weak, medium subangular blocky structure; common, medium dark brown (10YR 4/3) and few dark brown (7.5YR 4/4) mottles. Abrupt, smooth boundary.
17-22 B3g	Dark grey (5Y 4/1) silt loam; massive; common, fine distinct dark brown (10YR 4/3) and 10% fine dark brown (7.5YR 4/4) mottles; some dark stains on cleavage faces; roots common. Abrupt, wavy boundary.
32-45 C1g	Dark greenish grey (5GY 4/1) silt loam; massive; discontinuous layer of very dark greyish brown (10YR 3/2) silt loam with organic matter (Alb?); common (20%) brown (10YR 5/3) mottles; few roots. Frost. 8 September 78.

Site: No Name Creek #565.4

Inter stripe area (see profile 565.3)

Classification: Pergelic Cryosaprist

Depth/Horizon (cm)	
0-8 Oi1	Dark yellowish brown (10YR 4/6) loosely matted fibrous moss; 5% sedge stem and sheath material. Abrupt, smooth boundary.
8-19 Oi2	Dark yellowish brown (10YR 4/4) loosely matted sedge stems, sheaths and fine roots. Abrupt, smooth boundary.
19-30 Oa1	Black (2.5Y N2/) sapric organic with dark brown (7.5YR 3/4) less decomposed root and wood fibers (chared); abundant charcoal. Radiocarbon date, Modern. Abrupt, smooth boundary.
30-40 Oa2f	Black (2.5Y N2/) sparic organic. Frozen 8 September 1978.

Site: No Name Creek #565.5

North facing slope below gravel upland.

Slope: 14%

Vegetation: _Picea mariana_; scattered _Betula papyrifera_. Considerable fired and fallen timber. _Ledum palustre; Empetrum eamesii_, _Vaccinium vit's idaea_, scattered Salix sp.; _V. uliginosum_

Classification: Pergelic Cryochrept

Remarks: _Picea glauca_ 200-250 years of age nearby; _B. papyrifera_ dominates crest areas on gravel; fire on site 25-30 years ago (?)

Depth/Horizon (cm)	
0-4 A	Very dark greyish brown (10YR 3/2 dry) finely divided organic matter and fine root fibers; loosely matted; approximately 30% silt. Abrupt, smooth boundary.
4-7 E	Dark brown (10YR 4/3 dry) dark brown (10YR 3/3 moist) silty clay loam; very fine moderate granular structure; many fine roots; sporadic charcoal fragments. Abrupt, smooth boundary.
7-16 B21g	Dark yellowish brown (10YR 4/4) moist silt loam; weak very fine granular structure; many fine roots; few large faint very pale brown (10YR 2/3 dry) and yellowish brown (10YR 5/4 moist) mottles. Abrupt, wavy boundary.
16-28 B22	Brown (10YR 5/3 dry), olive brown (10YR 4/4 moist) silt loam; weak fine angular blocky structure; 10% siltstone gravel fragments (< 2 cm) with continuous

Depth/Horizon (cm)	
16-28 (cont'd) B22	thin silt coats (some to 1 mm thick); many fragments with limonite (or redder) areas; patches of dark yellowish brown (10YR 4/4) silt loam enmixed. Aburpt, wavy boundary.
28-65 IIB3	Dark yellowish brown (10YR 4/4 - slightly more red than B22) loam; weak very fine subangular blocky structure; gravel fragments 20% - 75% are less than 2cm and rotted. Fragments with continuous silt coats; iron coats below; few roots; patches of dark brown (7.5YR 4/4) in lower 10 cm. Abrupt, wavy boundary.
65-74 IIC1	Dark greyish brown (10YR 4/2) silt loam; massive; 15% pebbles with continuous thin silt coats; very few roots; few small enmixed patches of dark brown (7.5YR 4/4) of clay loam. Profile terminated 9 September 1978.

Site: No Name Creek #566.1

Alluvial fan or gravel terrace remnant; north side of creek, base of spruce slope.

Slope: 2-4%

Vegetation: Picea glauca (to 16 m); understory Salix sp. moss carpet Ledum sp.; occasional Lupine; large squirrel mounds of spruce cones, evidence of fire.

Classification: Pergelic Cryochrept

Depth/Horizon (cm)	
3-0	Moss carpet, fungi numerous at base.
0-5 A11	Dark reddish brown (5YR 5/2) organic silt loam; friable; structureless; roots abundant; charcoal fragments common. Abrupt, wavy boundary.
5-15 E	Very dark greyish brown (10YR 3/2) silt loam; moist; friable; breaks to strong coarse subangular blocky structure, roots abundant. Abrupt, wavy boundary.
15-23 B21	Brown (10YR 5/3) silt loam; moist; friable; strong very fine subangular blocky structure; roots common; few root and charcoal fragments. Abrupt, wavy boundary.
23-36 B22	Brown (10YR 5/3) silt loam; moist; friable; weak medium angular blocky structure; roots common. Abrupt, wavy boundary.
36-51 C1	Brown (10YR 5/3) silt loam; moist; friable; weak fine peaty structure; breaks to weak coarse angular blocky

Depth/Horizon (cm)	
36-51 cont'd)	structure; roots common; smears and inclusions of dark brown (10YR 3/3) organic; reacts to HCL. Abrupt, wavy boundary.
51-60 C2g	Greyish brown (10YR 5/2) silt loam; moist; friable; lense of greyish brown (10YR 5/2) very fine gravelly silt loam; weak fine platy structure; coarse sand on some plate boundaries; breaks to weak coarse angular blocky structure; weak fine yellowish brown (10YR 6/6) mottles; few roots; discontinuous streaks of very dark greyish brown (10YR 3/2) organic rich silt loam. Abrupt, wavy boundary; reacts to HCl.
69-79 IIC3	Brown (10YR 5/3) fine gravelly medium sand with sporadic carbonate coats.
79-119 IIIC4	Dark greyish brown (10YR 4/2) silt loam; pebbles common. Frost.

Site: No Name Creek #566.1A (see #566.1)

Slope: 3%

Vegetation: *Picea glausa* (old stand) *Alnus* sp., *Empetrum eamesii*.

Classification: Pergelic Cryochrept

Depth/Horizon (cm)	
0-5 A1	Black (10YR 2/1) sapric organic matter with many fungal hyphae; approximately 50% silt loam; many large and medium roots. Abrupt, smooth boundary.
5-9 E	Dark greyish brown (10YR 4/2 dry), very dark greyish brown (10YR 3/2 moist) silt loam; weak very fine granular structure; many fine roots. Abrupt, wavy boundary.
9-20 B21	Very dark greyish brown (2.5Y 3/2) silt loam; weak fine subangular blocky structure; some disseminated organic matter; roots common; reaction to HCl Abrupt, wavy boundary.
20-33 B22	Dark greyish brown (2.5Y 4/2) silt loam; fine platy to very fine angular blocky structure; vigorous reaction to HCl. Gradual boundary.
33-66 C1	Olive (5Y 4/3) silt loam; fine platy to weak fine angular blocky structure; few roots, vigorous reaction to HCl. Abrupt, wavy boundary.
66-112 C2g	Olive (5Y 4/2) silt loam; moderate, medium platy structure; plate faces commonly gleyed; common fine grey (5Y 5/1) mottles. Frost. September 9, 1978

Site: No Name Creek #566.3

Ridge portion of ridge and watertrack.

Slope: 5%

Vegetation: Picea mariana (dense regeneration growth) few 2-4 m corpses. Vaccinium uliginosum; V. vitis-idaea; Salix sp.; Ledum sp.; Petasites frigidus; scattered grasses; moss mat.

Classification: Pergelic Cryaquept

Depth/Horizon (cm)	
3-0	Live vegetation
0-4 Oi	Dark reddish brown (5YR 3/4) fibrous organic; loose and spongy; root fragments common; live roots common. Abrupt, smooth boundary.
4-8 Oe	Dark reddish brown (5YR 3/2) hemic/sapric organic; breaks down nearly completely; friable; live roots few; few coarse root fragments; many fine root fragments. Abrupt, smooth boundary.
8-10 A11	Dark reddish brown (5YR 2.5/2) organic silt loam; breaks to weak, fine granular; live roots common; root fragments common; few large stem fragments. Abrupt, wavy boundary.
10-14 A12	Very dark greyish brown (10YR 3/2) silt loam; friable; weak fine granular structure; many live roots; many root and charcoal fragments. Abrupt, smooth boundary.
14-61 B2g	Very dark greyish brown (2.5Y 3/2) silt loam; strong fine platy structure; lense shaped, black (10YR 2/1)

Depth/Horizon (cm)	
14-61 (cont'd	organic inclusions; medium weak dark yellowish brown (10YR 4/6-3/6) mottles; few strong dark grey (5Y 4/1) mottles; few roots; few charcoal fragments. Frost. 4 September 1977.

Site: No Name Creek #566.5

Abandoned stream terrace.

Slope: ~ 0%

Vegetation: Betula papyrifera - lichen open area

Remarks: Loess enmixed in upper horizons

Classification: Pergelic Cryochrept

Depth/Horizon (cm)	
0-2 A1	Black(7.5YR 2/) organic silt loam; 10% quartz gravels mostly < 1/2 cm; many charcoal fragments. Abrupt, wavy boundary.
2-5 E	Dark yellowish brown (10YR 4/4 moist), dark brown (10YR 2/3 dry) silt loam; weak fine granular structure; approximately 13% angular quartz fragments; no silt coats; many fine roots. Abrupt, smooth boundary.
5-9 B21	Dark brown (7.5YR 4/4) silt loam; weak fine platy structure breaking to weak very fine angular blocky structure; coarse gravel fragments 13%; medium (1 mm) continuous silt coats; (gravels consist of schists, siltstones and quartz, some rounded-some subrounded); roots common. Abrupt, smooth boundary.
9-15 B22	Dark yellowish brown (10YR 4/4 moist); yellowish brown (10YR 5/6) gravelly silt loam; subrounded quartz pebbles 25% with continuous medium silt coats; roots common. Abrupt, smooth boundary.

No Name Creek#566.5

Depth/Horizon (cm)	
15-26 B23	Dark yellowish brown (10YR 4/4 moist) gravelly coarse sandy loam; loose; 45% gravel with continuous medium silt coats; 75% of gravel < 1/2 cm (mostly quartz); coarser gravel is rounded and subrounded quartz, granite, and metamorphics; few roots. Abrupt, smooth boundary.
26-40 IIC1	Dark yellowish brown (10YR 4/4) gravelly loamy coarse sand; loose; 70% gravel, 80% < 1/2 cm; mostly quartz fragments; larger fragments are rounded and have continuous silt coats. Abrupt, smooth boundary.
40-60 IIC2	Dark yellowish brown (10YR 4/4) gravelly coarse sand; loose; 90% gravel, 80% > 1/2 cm; continuous silt coats on larger fragments, discontinuous on smaller fragments. Profile terminated.

Site: No Name Creek #567.1

South facing, black spruce slope, frost scar element

Slope: 5%

Vegetation: Piccea mariana; scattered Betula sp., moss

Classification: Pergelic Cryaquept

Depth/Horizon (cm)	
3-0	Living moss
0-4 Oi1	Reddish brown (5YR 5/3) fibrous organic; wood fragments common; roots abundant. Abrupt, wavy boundary.
4-9 Oa1	Black (7.5YR N2/) sparic organic, friable; weak fine granular structure; few wood fragments; roots common. Abrupt, wavy boundary.
9-15 B21g	Dark greyish brown (10YR 4/2) micaceous silt loam; friable; weak fine dark yellowish brown (10YR 3/4) mottles. Abrupt, wavy boundary.
15-27 B22g	Dark greyish brown (10YR 4/2) micaceous silt loam; weak medium platy structure; slightly thixotropic; common, weak fine very dark greyish brown (2.5Y 3/2) mottles; roots common. Clear, wavy boundary.
27-37 BCg	Dark greyish brown (2.5Y 3/2) micaceous silt loam; weak fine platy structure; many with fine dark yellowish brown (10YR 4/6) mottles; inclusions of very dark grey organic rich silt loam; roots common. Abrupt, wavy boundary.

No Name Creek #567.1

Depth/Horizon (cm)	
37-48 IIA1b/C1	Black (7.5YR N2/) organic silt loam; weak fine granular structure enmixtures of BCg horizon; many roots. Abrupt, wavy boundary.
48-53 IIIC2g	Dark greyish brown (2.5Y 4/2) silt loam; weak fine platy structure; few weak fine dark yellowish brown (10YR 4/4-4/6) mottles; few roots. Abrupt, wavy boundary.
53-57 IVA1b/C3	Very dark greyish brown (10YR 3/2) and black (10YR 2/1) mixed silt loam and sapric organic materials; few roots. Frost 3 September 1977.

Site: No Name Creek #567.2

Moss hummock area adjacent to Profile 567.3

Vegetation: Sphagnum sp.; Eriophorum vaginatum; Betula sp.; Vaccinium vitis-idaea

Classification: Pergelic Cryaquept

Depth/Horizon (cm)	
3-0	Living moss
0-5 Oil	Dark reddish brown (5YR 3/2-3/3) fibrous organic; loose, roots common. Abrupt, smooth boundary.
5-8 Oal	Black (7.5YR N/2) sapric organic, friable; weak fine granular structure; few charcoal fragments; roots common. Abrupt, wavy boundary.
8-24 Clg	Very dark grey (10YR 3/1) silt loam; friable; sedge fragments common; few weak medium dark yellowish brown (10YR 3/4) mottles; few roots. Abrupt, wavy structure.
25-37 C2g	Very dark greyish brown (10YR 3/2) silt loam; weak fine platy structure; sedge fragments common; common, strong fine strong brown (7.5YR 4/6) mottles, roots common. Frost 3 September 1977.

Appendix C

Area (% of Total) summary for all soil landform map units appearing in Fig. 74.

Map Unit	Area (%)	Map Unit	Area (%)
1,1,1	.69	3,3,1	.35
1,2.1	6.32	3,8,1	.22
1,2,2	2.74	3,8,3	.08
1,3,1	5.78	4-1,7,3	6.81
1,3,2	1.50	4-1,8,3	2.52
1-3,2,1	6.62	4,7,3	1.93
1-3,6,2	6.43	4,8,3	.96
1-3,6,2	6.85	5-3,4a,1	6.80
1-3,8,2	2.31	5,4,1	6.79
1-4,7,1	.72	5,8,1	.16
1,6a,2	5.60	Rx	.88
1,6,2	6.73	L	.06
1,6,3	6.62	No Name Creek	1.64
1,8,3	.08	X	6.77
2,5,1	.54	D	.72
3,1,1	3.80		

Summary

The poorly drained soils

The great instability of the land surfaces within the permafrost zone of northern Alaska especially north of the southern margin of the Brooks Range coupled with cold wet soil conditions has contributed to a soil cover in which profile morphology is poorly expressed and highly variable from point to point on the landscape (see Tedrow, 1977 and Everett *et al.*, 1981 and Everett, 1980). Probably, with few exceptions this landscape (and landform) instability is sufficiently great that active soil profiles, i.e., those in the process of differentiation with ages greater than 15,000 years do not exist. Most are probably less than 5000 years old.

Within the several taxa of poorly drained soils recognized throughout the study area (Pergelic Cryaquepts, Histic Pergelic Cryaquepts and Histosols) three broadly defined processes are operating: (1) gleization, (2) congeliturbation, and (3) organic accretion.

Manganese and iron occur in soil systems in both oxidized and/or reduced forms; which is present at a given time depends upon the oxygen concentration of the soil and/or the pH. Manganese may be in the form of hydrated manganic oxide which, may under weakly acid conditions, covert to manganese dioxide and bivalent manganese. Iron can occur in both the mono and divialent forms in tundra soils. In the absence of oxygen it occurs in ferrous compounds imparting a grey or bluish-grey color. The reduction of ferric iron to the ferrous form is favored by the presence of organic matter, especially if soil pH is near neutrality. In the presence of oxygen, around roots and in soil solution the ferric form is produced

mostly by biological oxidation. The results of these processes, when viewed in the soil as bright yellowish-red mottles and in grey matrix, is referred to as gleying (gleization). In some gleyed soils the process is favored by a fluctuating water table.

Because such a high percentage of Coastal Plain soils, as exemplified at Prudhoe Bay, Lonely or Barrow sites, are saturated to the surface or have standing water much of the iron and manganese is in the reduced form (and mobile) and the grey-grey blue soil colors dominate even around aerenchymus roots.

The wet soils of the Foothills (tussock tundra) as a whole display a lower degree of gley colors and much more mottling. These soils may become partially unsaturated for brief periods permitting oxidation. That the near surface, upper 10 cm or so become oxignated in these wet soils is attested to by the complex precipitates of iron-manganese-humates (Everett, 1979). It is also possible that the aerenchymus tissue of the dominant sedge Eriophorum vaginatum may be more effective than Carex in oxygenating its immediate environment. Similar conditions seem to prevail in the tussock-spruce forests south of the Brooks Range. The course of downward moving oxygenated waters has not been investigated but there is circumstantial evidence this may occur (A. Linkins and T. Chapin, unpublished data).

Mineral weathering and synthesis is very slow in these cold wet soils. Thus, it is not surprising that relatively small amounts of soluble (exchangeable) metal ions are present. Mineral cycling to plants is mostly through biological decomposition (organic matter) and mineralization by microbial organisms - processes pretty much restricted to the upper

10 cm of the soil. Most plants are subject to mineral limitations especially phosphorus, most of which is tied up in the organic materials of the upper horizons. This element also complexes readily with iron and calcium (Chapin et al., 1978).

Clay mineralogy of the soils tracks that of the surrounding bedrock and there is very little evidence of synthesis or modification of the primary clay minerals. Reynolds and van Oss (1980) have shown some breakdown in chlorite crystallization in some soils relative to that in the surrounding bedrock. This is in contrast to the significant transformation in the well drained soils. Lepidocrocite is common to most clay mineral suites taken from the wet soils.

It is likely that much of the volume of potentially weatherable minerals found in the upper horizons of the organic soils, especially, are derived from air infall, most commonly loess.

The processes of cryoturbation (especially in the form of frost scars) is especially important although by no means restricted to the region north of the Taiga. It is particularly important in the Foothills tussock tundra and on the somewhat better drained surfaces on the Coastal Plain where it serves to incorporate through burial and/or vertical mixing (Fig. 80) surface and near surface organic materials. This process not only interrupts adjacent soil profiles but complicates profile morphology. Melting of the pronounced ice segregations that accompany frost heaving, and summer desiccation cracking contribute to air circulation within the frost scars. Mottling in these features is usually pronounced.

Fig 80. Well developed frost scars composed of silt loam interrupting Histic Pergelic Cryaquepts at Cape Thompson. A weakly defined stripe pattern has developed in response to slight slope gradient. The soil is classified as a Ruptic Histic Pergelic Cryaquept.

The cool summer temperatures, saturated or near saturated state of the soil and/or vegetation and low evaporation rate favor the retention of organic matter and the development of Histic epipedons or organic soils (peats) throughout much of the study area. Within the Coastal Plain Province the distribution of these soils is greater and more uniform than in the Foothills and Taiga region to the south (Table 2). It is likely that north of the Continental Divide sites were available and climatic conditions were favorable for the accumulation of organic matter by between 14,000 and 12,000 years ago (M. Bergman, personal communication; Hamilton and Porter, 1975; Brown, 1965; Carter, 1981; Everett, 1979 and various sections of this report).

It is not known with any degree of precision how the rates or organic matter accumulation have varied through time within the study area. Philip Miller (1981) has calculated, using the soils data and radiocarbon dates from this report as well as other published data, that annual accumulation of organic matter in tundra is about 40% of annual primary production. In bogs (Histosols) it amounts to 64% of annual primary production. Organic matter accumulation rates measured as increase in thickness for the tundra (Coastal Plain and Foothills combined) range between 0.03 and 0.05 cm/yr. and for the Taiga between 0.07 and 0.17 cm/yr.

The well-drained soils

In the process of soil landscape studies conducted within this region special attention was paid to soils on stable (old) well-drained sites distributed along the major north to south gradient both within the confines of the north slope and along the Yukon River-Prudhoe Bay haul road.

The well-drained soils occupy sand dunes, pingos and gravel terraces on the Coastal Plain; terraces and ridge tops in the Arctic Foothills; alluvial fans, glacial moraines and kame terraces in the Brooks Range. South of the Brooks Range well-drained soils occur on gravel terraces, gravel covered ridges and in deposits of weathered granite. In these situations a capping of loess is commonly present. Such soils should reflect the degree to which the processes of acid leaching and profile differentiation which (Podzolization) are essentially unidirectional, have acted in the region with respect to climatic gradients.

In a broader context of soil genesis such a study might establish the validity of the proposition that the processes of Podzolization remained the same as one proceeded north but lessened in intensity (Tedrow, 1968; 1977; Everett, 1968). In addition the results of the study could be used to establish a suitable taxonomic position for these soils which are now regarded as Inceptisols (Cryochrepts) or in some cases Entisols (Cryopsamments or Cryorthents). If the soils are to be regarded as belonging to the order Spodosols (soils displaying the full impact of the processes of Podzolization) they must have one or more subhorizons in which the following criteria are met.

(1) If there is a 0.1 percent or more extractable iron, the ratio of iron plus aluminum (elemental) extractable by pyrophosphate at pH 10 to percentage of clay is ≥ 0.2 (percentage of pyrophosphate-extractable Fe + Al at pH 10 ÷ clay percentage ≥ 0.2),

(2) Of if there is ≥ 0.1 percent extractable iron, the ratio of aluminum plus carbon to clay is ≥ 0.2 (percentage of pyrophosphate-extractable Al + C ÷ clay percentage ≥ 0.2),

(3) The sum of pyrophosphate-extractible iron plus aluminum is half or more of the sum of dithionite-citrate extractable iron plus aluminum (percentage of pyrophosphate-extractable Fe + Al ÷ percentage of dithionite-citrate extractable Fe + Al ≥ 0.5),

(4) The combined index of accumulation of amorphous material must be 65 or more. The index for each subhorizon is calculated by subtracting half of the clay percentage from CEC at pH 8.2 and multiplying the remainder by the thickness of the subhorizons are then added and the total must be 65 or more (Soil Survey Staff, 1975).

<u>The purpose of the first criterion is to establish a measurement and minimal level of precipitated iron and aluminum in complex with organic matter</u>. Sodium pyrophosphate at pH 10 is a good indicator of the presence of iron and aluminum in complex with organic matter because it readily extracts iron plus aluminum from organic matter but does not extract much iron and aluminum from amorphous and crystalline aluminum silicates or from hydrous oxides of iron and aluminum (Soil Survey Staff, 1975). Since small amounts of iron and aluminum associated with silicate clay is also removed by pyrophosphate the percentage clay must also be

considered in relation to the percentage iron and aluminum removed by pyrophosphate. Thus the ratio of pyrophosphate extractable iron plus aluminum to percent clay is a respectable yardstick and useful for establishing a minimal level of precipitated iron and aluminum in complex with organic matter in order for a horizon to qualify as a spodic.

The purpose of criterion (2) is to establish a measurement and minimal level of precipitated organic matter in complex with aluminum for soils extremely low in iron. The objective of criterion (2) is accomplished by establishing a minimal level of pyrophosphate aluminum plus carbon relative to percent clay for an horizon to qualify as a spodic. Soils with less than 0.1% iron generally are saturated with water for long periods of time. Most of the study sites had more than 0.1% iron, as would be expected for well-drained soils. The two B horizons in the study that had less than 0.1% iron were coarse grained and low in weatherable minerals.

The purpose of criterion (3) is to eliminate horizons that may be high in iron and aluminum but that lack sufficient accumulation of iron and aluminum complexed with organic matter. Dithionite-citrate is a useful reagent because it is a general extractant, removing iron and aluminum from the amorphous and crystalline aluminum silicates, the hydrous oxides of iron and aluminum, in addition to removing iron and that is in complex with organic matter. In contrast, sodium phrophosphate is a specific extractant mostly removing iron and aluminim in complex with organic matter (Soil Survey Staff, 1975). The ratio of pyrophosphate-extractable iron plus aluminum to dithionite-citrate-extractable

iron plus aluminum is thus a good measurement for determining what approximate percent of the iron and aluminum present in the soil is complexed with organic matter and is likely to have been moved down in the profile.

Criteria (4) establishes a minimal level of precipitated amorphous materials. The high cation-exchange capacity of the amorphous materials is used to set this limit. A correction must be made for clay because part of the Cation Exchange Capacity is determined by the percentage of clay.

Cation Exchange Capacity measured in meq/100 grams soil, minus one half the measured clay percentage is multiplied by the horizon thickness in cm so that the index of accumulation indicates total amorphous organic matter rather than the concentration of amorphous organic matter. The index thus enables one to compare total accumulation of amorphous organic in horizons that are thin and that have a high percentage of amorphous material to horizons that are thick with small percentage of amorphous material.

Criteria (1), (3), and (4) must be met for a horizon to be classified as a spodic if the percent of pyrophosphate iron is greater than 0.1% or criteria (2), (3) and (4) must be met for a horizon to be classified as a spodic if the percent pyrophosphate iron is less than 0.1%.

Fourteen horizons were selected from ten well drained soil profiles for comparative study with respect to the four criterion just described. All but two of the B horizons had greater than 0.1% iron. The B horizons having greater than 0.1% iron had a ratio; percent pyrophosphate iron

plus aluminum to percent clay that ranged from 0.01 to 0.1 or, between 5% and 50% respectively of the pyrophosphate iron plus aluminum necessary to meet criterion (1). Thus these B horizons fail to qualify as spodic. On the basis of criteria (1) alone all but two horizons are eliminated as potential spodic horizons. The remaining two B horizons have less than 0.1% pyrophosphate iron and could be tested against criterion (2).

Here the ratio of percent pyrophosphate iron plus aluminum to per clay averaged 0.025 or 15% of the pyrophosphate iron plus aluminum necessary to qualify the horizons as spodic (Fig. 81).

The two B horizons in the transect with less than 0.1% extractable iron had ratios of percent pyrophosphate aluminum plus organic carbon to percent clay of 0.05 and 0.9, or 25% and 450% respectively of the aluminum, plus carbon necessary for the horizon to qualify as a spodic on the basis of criteria (2) (Fig. 82). However, the profile located at Archimedes Ridge UTU #1 (81.1 Appendix B, pg. 98) with 450% of the required aluminum plus carbon failed to meet criteria (3) (Fig. 83).

None of the soil horizons qualified as spodic with reference to criteria (3). The ratio of the percent pyrophosphate iron plus aluminum to percent dithionite citrate iron plus aluminum range from 0.05 to 0.46 or from 10% to 92% respectively of the required pyrophosphate iron plus aluminum. Figure 81 shows the distribution of percent pyrophosphate iron plus aluminum required to meet criteria (3). It will be noted there is no trend along the north to south transect.

Most of the horizons on the transect met criteria (4) as they have a combined index of accumulation > 65 (Fig. 83). Indexes ranged from 22 to 357 or

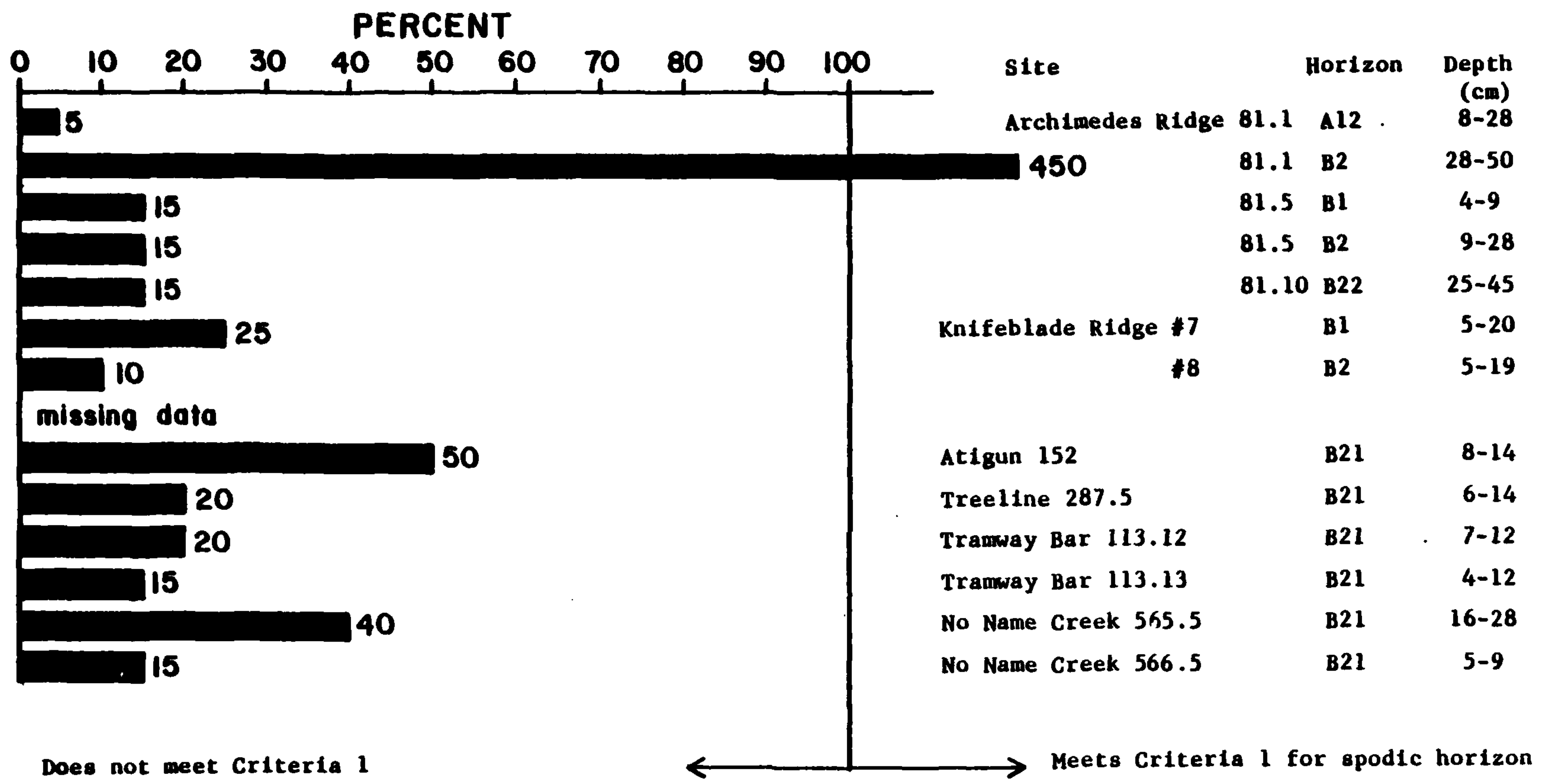


Fig. 81. Percent compliance pyrophosphate Fe+Al to Criteria 1 for a spodic horizon.

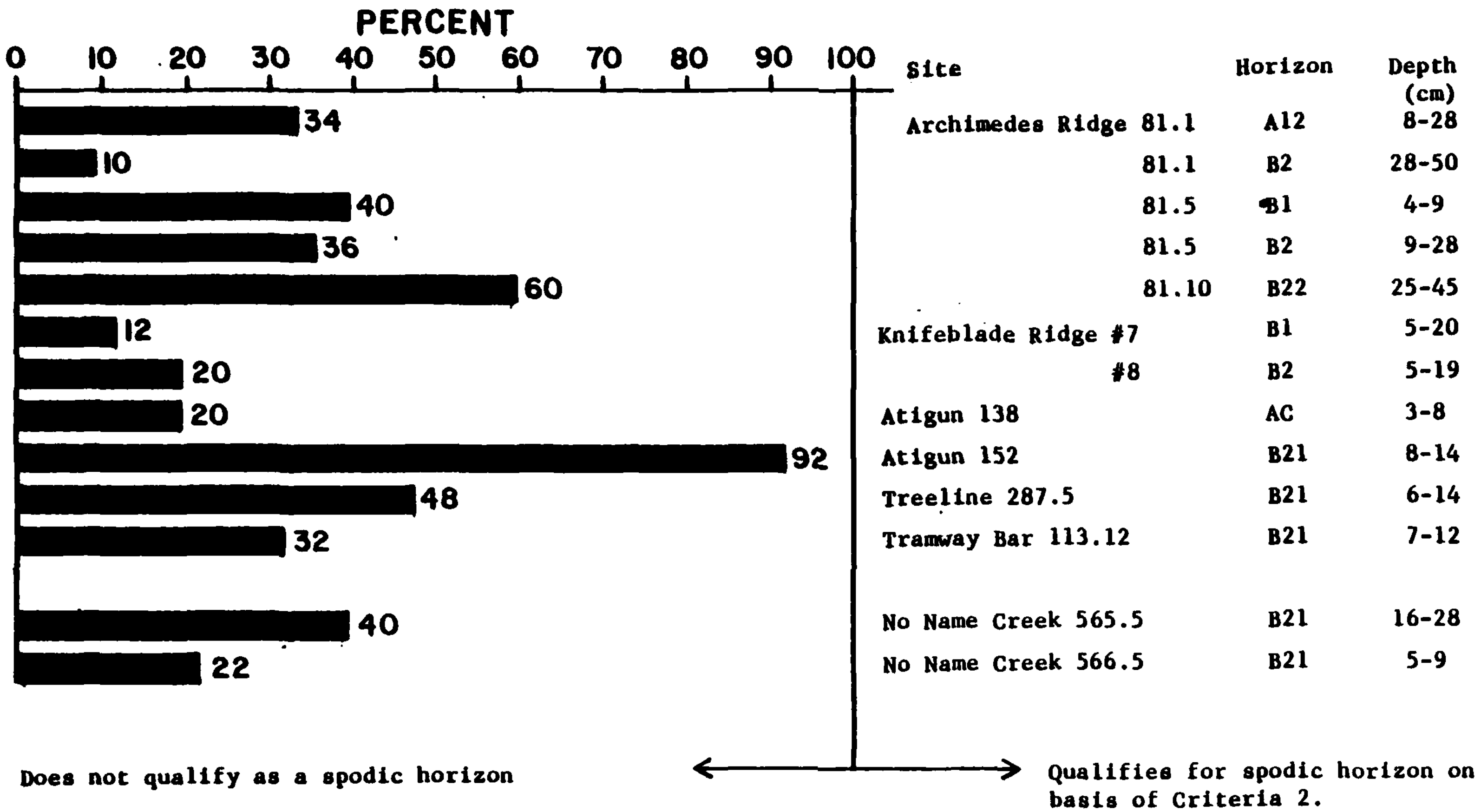


Fig. 82. Percent compliance of pyrophosphate Fe+Al to Criteria 2 for a spodic horizon.

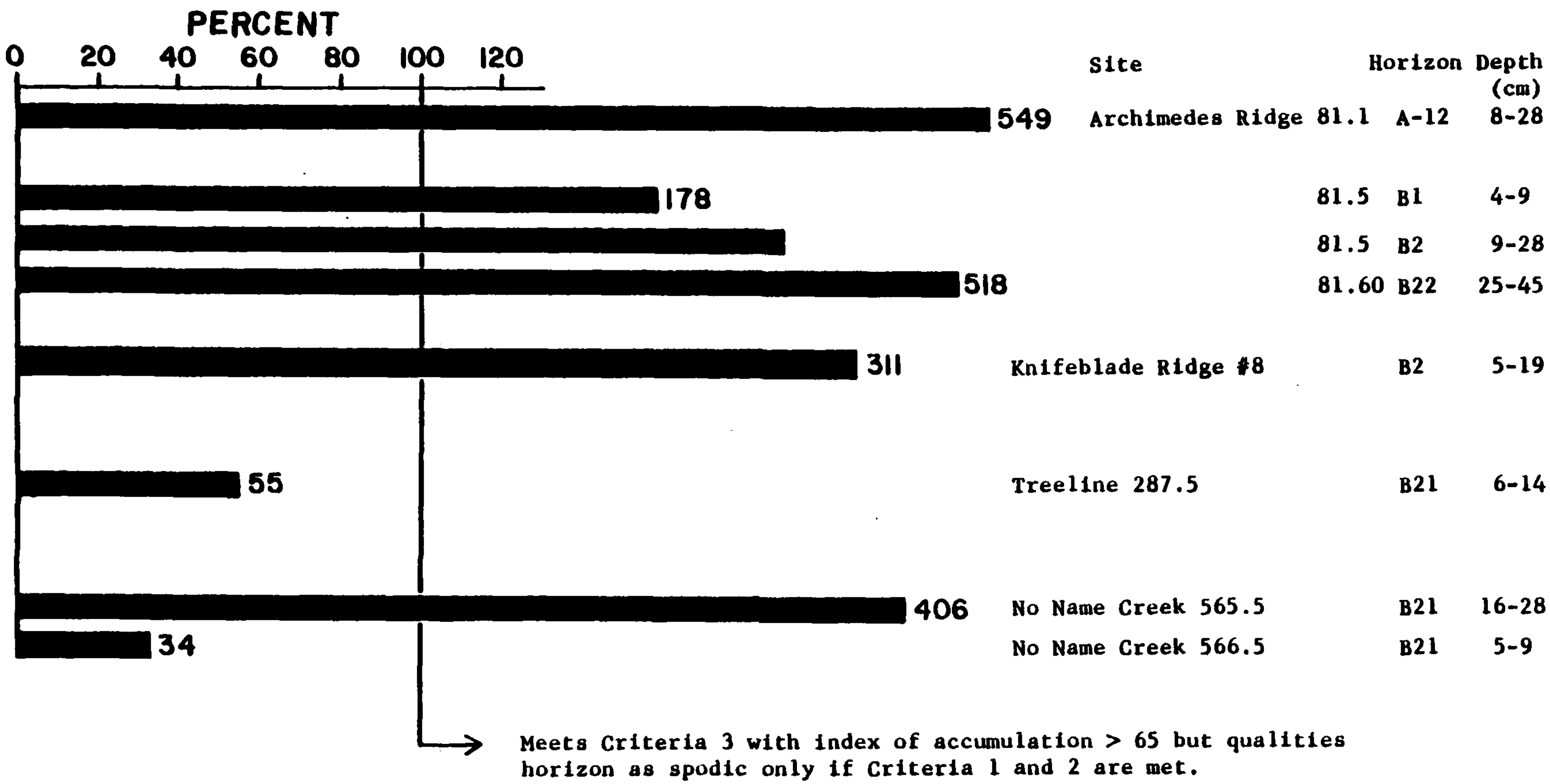


Fig. 83. Percent compliance of the combined index of accumulation necessary to qualify the spodic horizon.

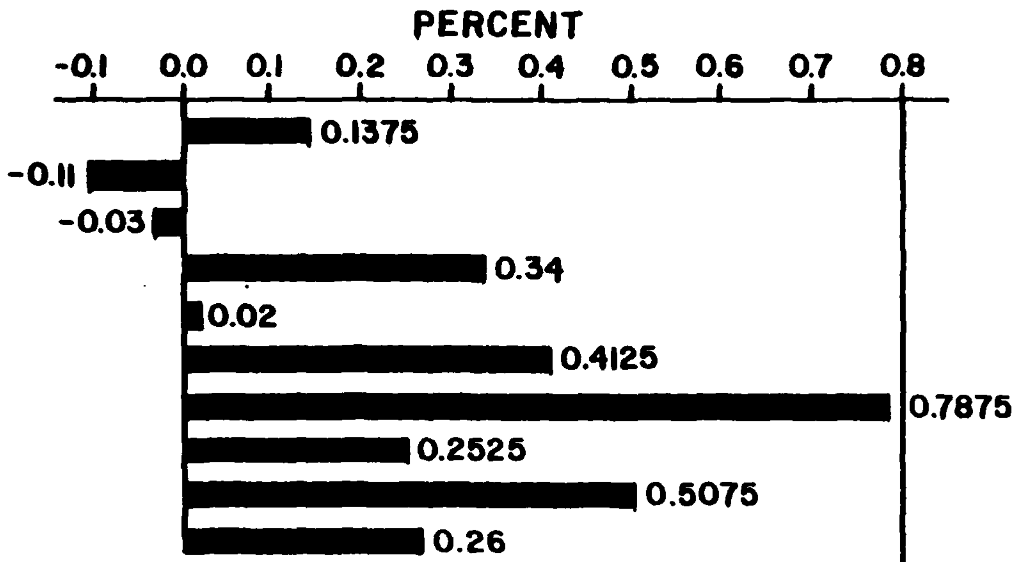
or 34% to 549% respectively of the required accumulation as computed according to criteria (4). Again no trend from north to south on the transect was evident.

Over all none of the soils studied have a spodic horizon, or even come close to having one, and no trend toward the development of Spodosols is evident from laboratory data. However it appears that the Archimedes Ridge site soil displayed the strongest development. This probably reflects the considerable age (and stability) of the terrace on which it occurs.

Figures 81 and 82 depict the laboratory data used in Figs. 84 through 86 with regard to criteria set forth for the Podzolic (Bh) horizon in the Canadian taxonomy (Canada Department of Agriculture, 1970). Again the soils generally fail to qualify as (Podzolic). The Archimedes Ridge terrace soils generally qualify as having a Bh horizon in Figs. 85 and 86 There also appears to be a weak trend developed in these data from north to south. Again probably reflecting the stability and age of the unglaciated Foothills sites.

Clay mineralogy:

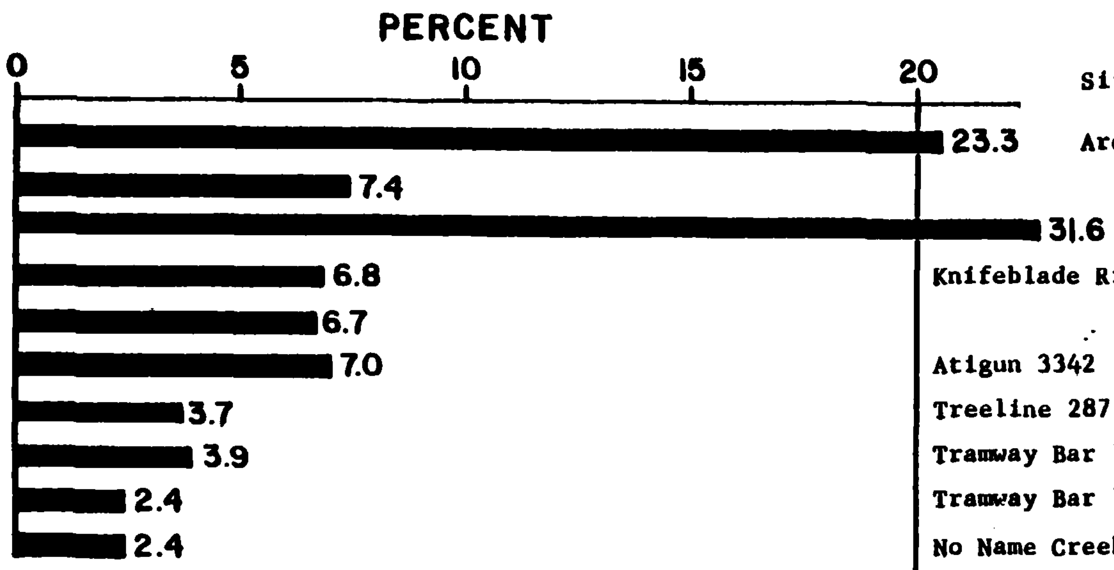
Whole profile clay mineralogy was examined for each of the well-drained soils selected for chemical analysis. In a way similar to the chemical data these data show no effect of a climatic gradient, but, due on an individual basis, reflect site stability and weathering intensity (age) Table 5. It is clear that the well-drained soils at Finger Mountain and Tramway Bar that have both an E horizon from which iron and humic materials have been leached and a relatively strongly developed B



Site	Horizon	Depth (cm)
Archimedes Ridge 81.5	B22	25-45
Atigun 138	AC	3-8
Atigun 152	B21	8-14
Atigun 3342	B21	3-12
Atigun 3342	B22	12-21
Treeline 287.5	B21	6-14
Tramway Bar 113.12	B21	7-12
Tramway Bar 113.13	B21	4-12
No Name Creek 565.5	B21	16-28
No Name Creek 566.5	B21	5-9

Difference > 0.8 qualifies the horizon as a B_f, B_{fh}, or B_{hf} Podzolic horizon if the % organic matter ÷ oxalate extractable Fe is < 20.
Horizon may still qualify as Bh Podzolic horizon.

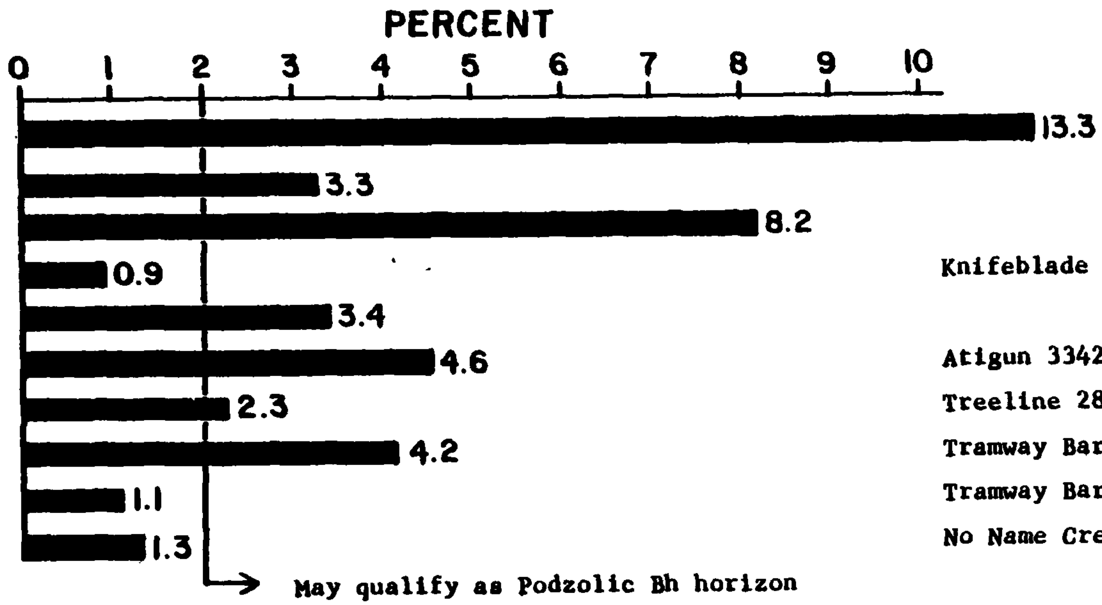
Fig. 84. Percent compliance of oxalate extractable Fe + Al in B - % Fe + Al in C1 horizon to qualify as a Podzolic horizon.



Site		Horizon	Depth (cm)	Thickness (cm)
Archimedes Ridge	81.5	B1	4-9	5
	81.5	B2	9-28	19
	81.10	B22	25-45	20
Knifeblade Ridge KNI#7		B1	5-20	15
KNI#8		B2	5-19	14
Atigun 3342		B21	3-12	9
Treeline 287.5		B21	6-14	8
Tramway Bar 113.12		B21	7-12	5
Tramway Bar 113.12		B22	12-22	10
No Name Creek 565.5		B21	16-28	12

Qualifies as Bh horizon if organic matter is > 2 percent and if thickness exceeds 10 cm.

Fig. 85. Percent compliance of organic matter : oxalate extractable Fe for Podzolic horizon.



Site		Horizon	Depth (cm)	Thickness (cm)
Archimedes Ridge		B1	4-9	5
UTU #5	81.5	B2	9-28	19
	81.10	B22	25-45	20
Knifeblade Ridge KNI#7		B1	5-20	15
KNI#8		B2	5-19	14
Atigun 3342		B21	3-12	9
Treeline 287.5		B21	6-14	8
Tramway Bar 113.12		B21	7-12	5
Tramway Bar 113.12		B22	12-22	10
No Name Creek 565.5		B21	16-28	12

Fig. 86. Percent compliance of organic matter for Podzolic horizon.

(Bh) horizons and significant amounts of oxalate extractable Fe + Al (Tramway Bar, Fig. 84) also have a clay mineral suite indicating intense weathering. This is also true of the Archimedes Ridge terrace soils - even though these generally lack both an E horizon and a Bh horizon.

TABLE 4

Comparative X-ray mineralogy of clay fraction from selected well drained soils (Orchrepts)

Site	Horizon	Clay minerals presented in order of relative abundance.										Remarks
[illegible]	[illegible]	CM	CH	K	V	L	F	INT:	CM	V		Interstratified clays, clay mica and vermiculite are soil clays derived probably from primary chlorite
	[illegible]	CM	CH	K	V	L	F	INT:	CM	V		
Pg [illegible]	[illegible]	CM	CH	K	V	L(?)	Q	F	INT:	V		
[illegible]	[illegible]	CM	CH	Q	F	INT:	CM	S				Chlorite is well crystallized and represents a primary mineral. The consistency of the mineral suite with depths suggests little weathering.
	[illegible]	CM	CH	Q	F	INT:	CM	S				
Pg [illegible]	[illegible]	CM	CH	Q	F	INT:	CM	S				
[illegible]	E	CM	CH	L	Q	F						Little weathering of primary minerals evident. Presence of Lepidocrocite is indicative of wetness. Consistency of mineral suite with depth suggests little weathering
	B21	CM	CH	L	Q	F						
Pg 178	B3	CM	CH	L	Q	F						
	C1g	CM	CH	L	Q	F						
113.13	E	CM	V	K,S	Q	F	G(?)	CH	INT:	CM	V	Composition of the E horizon may reflect the loess cap (fresher less weathered materials). Aluminum interlayered vermiculite indicates intense development (weathering) in B horizon. *Goethite peaks are well* defined except in E horizon.
	B21	CM	V*	K(?)	Q	F	G	CH	INT:	CM	V	
	B22	CM	V*	K(?)	Q	F	G	CH	INT:	CM	V	
Pg 243	B23	CM	V*	K(?)	Q	F	G	CH	INT:	CM	V,S	
	B3	CM	V	K(?)	Q	F	G	CH	INT:	CM	V	
	IIC1	CM	V	K(?)	Q	F	G	CH	INT:	CM		
606.20	E	CM	K	Q	F	INT:	CM	S	V			Clays are generally poorly crystallized relative to 113.13. Aluminum interlayered vermiculite indicates substantial weathering.
	B211	CM	K	Q	F	V	INT:	S	V			
	B22	CM	K	Q	F	V*						
Pg 270	B21b	CM	[illegible]	Q	F	V*						
	C1	CM	K	Q	F	V*	CH	G(?)	L(?)			
566.5	B21	V*	Q	F	K(?)							Aluminum interlayering in vermiculite is strongly developed indicating intense weathering. Kaolinite appears to be ramdomly interstratified with a 2·1 clay mineral. Lower horizons may have loess enmixed.
	B22	V*	Q	F	K(?)							
	B3	V*	Q	F	K	CM	INT:	K	2·1 clay mineral			
Pg 310	C1	V*	Q	F	K	CM	INT·	K	2·1 clay mineral			
NBX50	A12	CM	V*	K	Q	F						Profile displays intense weathering. Aluminum interlayering in vermiculite is strong and decreases with depth. Kaolinite is well crystallized.
	B21	CM	V*	K	Q	F						
	B22	CM	V*	K	Q	F						

CM Clay mica
CH Chlorite
K Kaolinite
V Vermiculite
V* Vermiculite with aluminum interlayers
Q Quartz
F Feldspar

G Goethite
INT: Interlayered clays
S Smectite
L Lepidocrocite

Pg refers to Appendix A for specific site profiles arranged Archimedes Ridge, Knifeblade Ridge, Treeline, Tramway Bar, Finger Mountain and No Name Creek. NBX 50 for comparison from unglaciated sandstone ridge, southeast Ohio.

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